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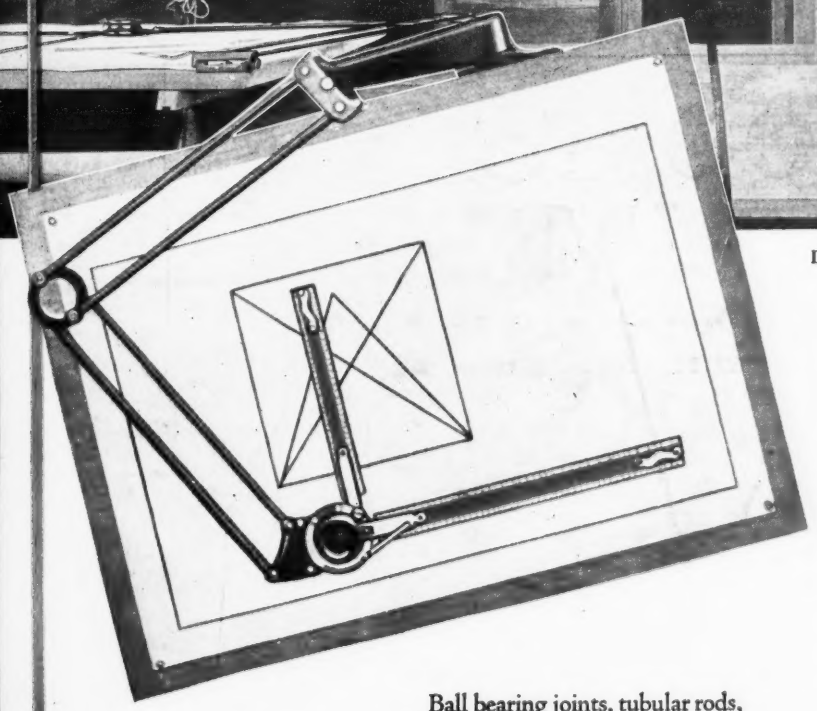

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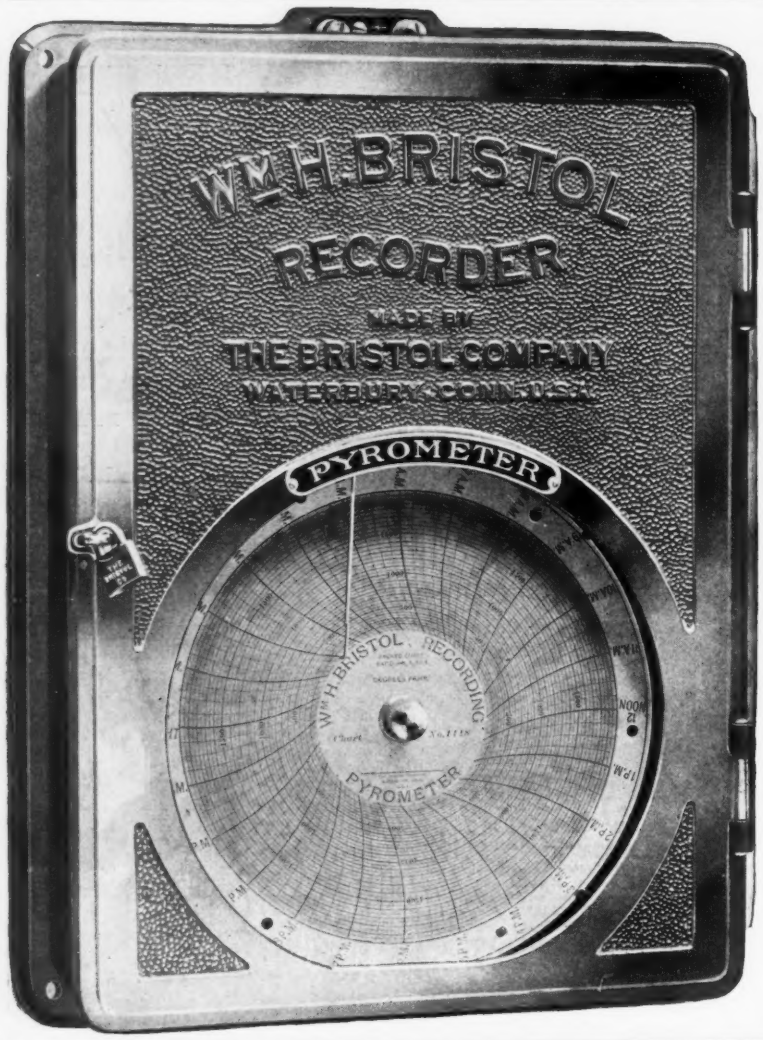
ADVERTISERS INDEX, PAGE 330—PRODUCT INDEX 310-328

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**AMERICAN VANADIUM COMPANY**
NEW YORK PITTSBURGH LONDON

# Training Apprentices[1]

## The Pratt & Whitney System of Making Skilled Mechanics

**The need of apprenticeships in American manufacturing plants is reflected in the great scarcity of trained machinists. Machine operators and specialists have their places, but men of general experience are also required. This article describes the apprenticeship system of the Pratt & Whitney Co. which was organized under the direction of B. M. W. Hanson for the express purpose of training men to be machinists. The company will depend upon these trained men for the future leaders in its factory.**

THE modern development of the manufacturing industries has firmly established the principles of specialization. Specialized methods have made feasible the employment of a larger proportion of unskilled and semi-skilled men in the industries than was possible in the earlier days, and less attention has been paid to the question of renewing the supply of skilled workers by training apprentices. As a consequence, the scarcity of skilled labor has become apparent during the last decade, and during the past few years manufacturers have been forced to consider the problem of reviving apprenticeship systems along lines which will meet the new industrial conditions. In re-establishing apprenticeship systems, however, many difficulties have had to be overcome. The conditions in modern manufacturing plants make it out of the question for the foremen to give the same attention to the apprentices that was common a generation or more ago. The changed conditions have also made it necessary that the apprentice of today should be trained along broader lines than in the past—he must be taught some of the principles on which his work depends, as well as the mechanical operations, and he must be made to understand not only the methods, but the reasons for the methods, so that he can adapt himself to new processes when required.

As a consequence, some of the larger companies in the machine-building field have established a more modern type of apprenticeship system in their plants. The apprentice schools of the General Electric Co. at Lynn and Schenectady, the New York Central Railway Co., the American Locomotive Works, and the Solway Process Co. may be mentioned as examples. Some of these apprentice schools, however, have been developed specifically for training young men for a special branch of the industry, and it has been left largely to the machine-tool builders to develop apprenticeship systems for training all-around mechanics who can take their place anywhere in the machine-building field. The machine-tool builders, in fact, have in the past been the leaders in training skilled mechanics, and among the plants which have turned out some of the best mechanics of the country, that of the Pratt & Whitney Co., of Hartford, Conn., occupies a prominent place. This company has maintained apprenticeship systems continually since its inception in the middle of the past century; and during the past few years this system has been developed along the modern lines made necessary by the changed conditions in mechanical practice and methods of management.

### Trade Schools and Apprenticeship Systems

When it became apparent that steps had to be taken to train skilled mechanics for the machine-building trades, trade schools were thought by many to present the solution of the problem. Some very good trade schools are maintained both by municipalities and by private enterprise, and these contribute a part of the training required. So-called half-time schools, which are maintained by the communities in which they are located in cooperation with manufacturing plants have also been tried with good results. In these, two groups of apprentices spend alternately one week in school and the next week in productive work in machine shops. This makes it possible for small shops to give their apprentices an opportunity for training. The expense of the teaching is, as a rule, borne by the public school system. Schools are also maintained by the coopera-

[1] For other articles on apprenticeship systems previously published in MACHINERY, see "Training the Apprentice," May, 1916; "More Light on the Selection of a Trade," May, 1916; "Training of Shop Teachers for Industrial Schools," September, 1915; "The Advantages of Manual Training High Schools," March, 1914; "A Modern Apprenticeship System," June, 1913; "Development of Skilled Mechanics," June, 1913; "Features of Apprenticeship System at the G. E. Co.'s Lynn Works," April, 1912; "Training of Machinists in the Trade School," July, 1911, and other articles there referred to.

tion of a number of employers whose apprentices attend classes during a limited number of hours each week. Evening schools are also maintained on a larger scale than ever, and tend to facilitate the education of apprentices. However, no one of these methods has proved to be as effective for the training of all-around machinists as the regular shop apprenticeship system. The real burden of training mechanics rests upon the industries themselves, to whom the supply of skilled mechanics is a necessity, and those companies that have recognized this and have taken steps to develop modern apprenticeship systems are making a real contribution to the solution of the all-important problem of maintaining a supply of skilled mechanics. The present article will review the Pratt & Whitney Co.'s apprenticeship system as studied by a member of MACHINERY's editorial staff.

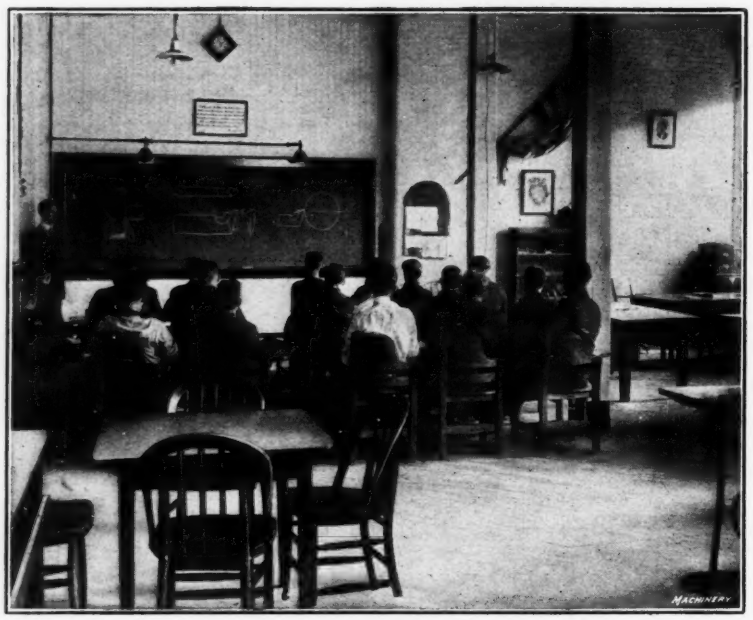


Fig. 1. A Lesson in Shop Practice in the Class-room

### Pratt & Whitney Co.'s Apprenticeship System

The apprenticeship system of the Pratt & Whitney Co. has been developed under the direction of B. M. W. Hanson, vice-president and general manager of the company. In the development of this system, Mr. Hanson laid down five cardinal conditions that are essential to the establishment of a successful undertaking of this kind, as follows:

1. The object of the apprenticeship system should be to produce machinists.

2. The working conditions in the factory must be such that the interests of the workmen and the factory are as nearly as possible interwoven.

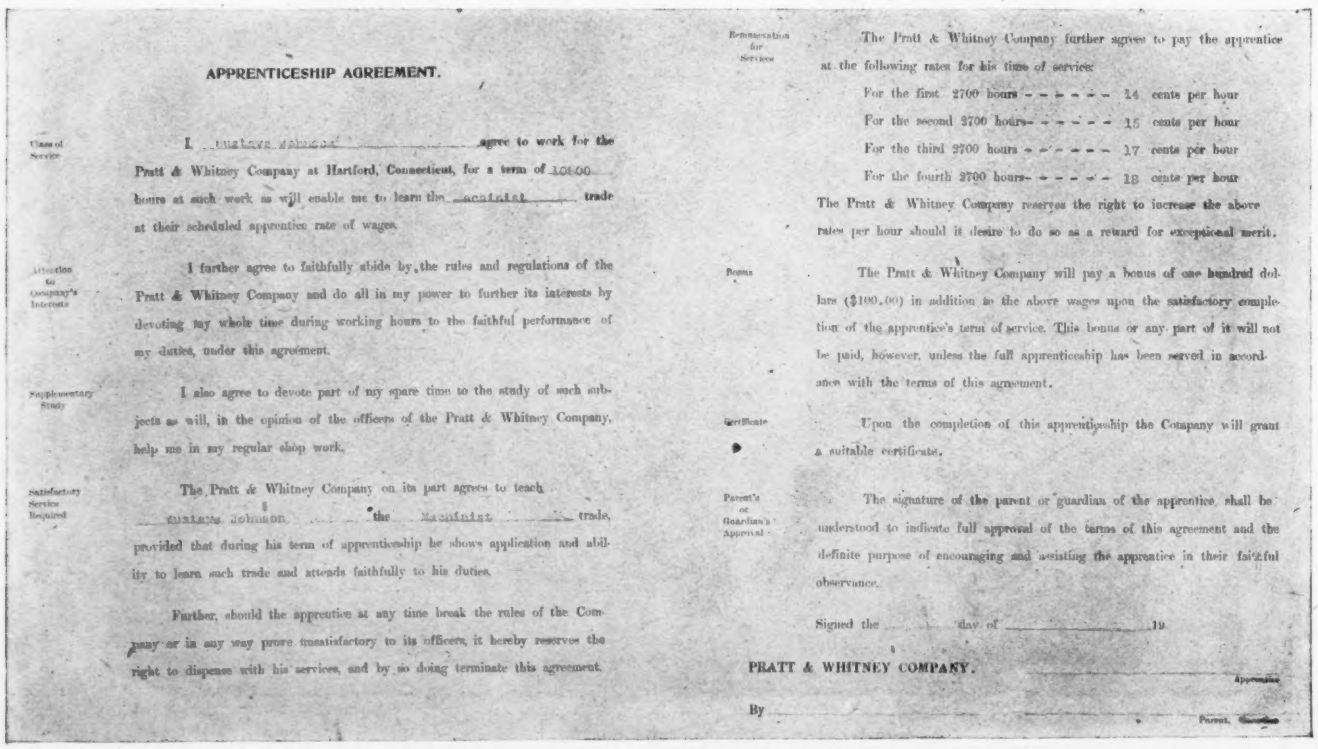
3. Every machinist in the employ of the company must be intelligent.

4. The company will depend upon its apprenticeship system for the future leaders in its factory.

5. Mechanical skill is not the only requirement a good mechanic should have; a great deal of attention must be paid to his moral and physical characteristics as well.

Great stress is laid upon the fact that the apprentice should realize that the calling of the machinist is an honorable and respectable one, and that all the men in the company's factory connected with mechanical work, from the vice-president and general manager down, are all primarily machinists. In referring to this point, in a recent interview, Mr. Hanson said: "I believe it is up to the management of machine shops to make the machinist's trade an honorable one, and I do not see any reason why the professional mechanic should not have as good a standing as the professional doctor or lawyer. If a doctor or a lawyer gives advice to his patients or his clients, and the latter do not obtain the result expected from the advice, they have to pay for it just the same; but whatever goods the mechanic delivers must be right, or he cannot get his pay. If a machine establishment ships a machine that does not do the work for which it is intended, it has to refund the money and take back the machine. Hence, the mechanical man is expected to do whatever he does right, and, considering the fact that more is expected of him than of many other members of the community, why should his work not also be considered as important and as honorable?"

In building up its modern apprenticeship system, the Pratt & Whitney Co. has therefore entered upon its task with a somewhat different spirit from that existing in the past. The fact has been recognized that it is as important to select the proper material for future mechanics as it is to test and select the material from which machinery is built. In a great many shops, a high-class purchasing agent is employed for buying



APPRENTICESHIP AGREEMENT.

Class of Service — I, [illegible], agree to work for the Pratt & Whitney Company at Hartford, Connecticut, for a term of 10800 hours at such work as will enable me to learn the machinist trade at their scheduled apprentice rate of wages.

Attention to Company's Interests — I further agree to faithfully abide by the rules and regulations of the Pratt & Whitney Company and do all in my power to further its interests by devoting my whole time during working hours to the faithful performance of my duties, under this agreement.

Supplementary Study — I also agree to devote part of my spare time to the study of such subjects as will, in the opinion of the officers of the Pratt & Whitney Company, help me in my regular shop work.

Satisfactory Service Required — The Pratt & Whitney Company on its part agrees to teach [illegible] the machinist trade, provided that during his term of apprenticeship he shows application and ability to learn such trade and attends faithfully to his duties.

Further, should the apprentice at any time break the rules of the Company or in any way prove unsatisfactory to its officers, it hereby reserves the right to dispense with his services, and by so doing terminate this agreement.

Remuneration for Services — The Pratt & Whitney Company further agrees to pay the apprentice at the following rates for his time of service:

For the first 2700 hours - - - - - - 14 cents per hour
For the second 2700 hours - - - - - - 15 cents per hour
For the third 2700 hours - - - - - - 17 cents per hour
For the fourth 2700 hours - - - - - - 18 cents per hour

The Pratt & Whitney Company reserves the right to increase the above rates per hour should it desire to do so as a reward for exceptional merit.

Bonus — The Pratt & Whitney Company will pay a bonus of one hundred dollars ($100.00) in addition to the above wages upon the satisfactory completion of the apprentice's term of service. This bonus or any part of it will not be paid, however, unless the full apprenticeship has been served in accordance with the terms of this agreement.

Certificate — Upon the completion of this apprenticeship the Company will grant a suitable certificate.

Parent's or Guardian's Approval — The signature of the parent or guardian of the apprentice shall be understood to indicate full approval of the terms of this agreement and the definite purpose of encouraging and assisting the apprentice in their faithful observance.

Signed the ____ day of _____ 19__

PRATT & WHITNEY COMPANY. _____ Apprentice

By _____ Parent, Guardian

Fig. 2. Pratt & Whitney Co.'s Apprenticeship Agreement

the materials used in production, but almost anyone is supposed to be capable of hiring men and taking in boys for training. This principle is now recognized as wrong, and great care is taken in selecting the proper material for training future mechanics.

### Supervision of the Apprenticeship System

In the old-time apprenticeship system, the boys were under the direct supervision of the foreman in whose department they were employed and were dependent upon him for all the instruction they received. Some foremen were good instructors and had the ability to train good mechanics; others were poor instructors, and the results were discouraging. Under modern shop conditions, the foremen, whether they are good or poor instructors, have so many other duties relating to the productive efficiency of the shop that it would be impossible to expect them to instruct or supervise the apprentices to any extent. All that the foreman can be expected to do is to give the apprentice his work, briefly outline to him the method of procedure, and see that his productive capacity and habits meet the requirements. In a large shop, also, there are so many departments, and the boys must be distributed under so many different foremen, that if the training were done entirely by the foremen there would be a great difference in the mechanical education of the boys trained in the same shop. Hence, all the apprentices at the Pratt & Whitney Co.—at the present time 135 in number—are directly in the charge of a supervisor of apprentices, H. F. Penney, who is responsible for the operation of the apprenticeship system just as the head of any manufacturing department is responsible for the results of production. The supervisor selects the boys, distributes them to the various foremen throughout the plant, changes them from time to time from one department to another, directs their class instruction, and, in general, acts as their counsellor and friend. A special room is set aside and equipped for the use of the boys, and this serves both as a class-room and as a lunch and reading room, and here the supervisor also has his headquarters. The boys come in classes of about twenty at a time for certain periods each week during working hours to receive instruction and training supplementary to that obtained in the regular productive work of the shop. An effort is made during these class hours to give the boys a general understanding of the fundamental principles that underlie all mechanical industries, and to make them appreciate their own branch of work, as well as to give them technical and specialized trade instruction. The details of the courses of study are given in a subsequent part of this article. The class-room, as mentioned, also serves as a social center for the boys where they can gather to eat their lunch and to read and play games every noon. The supervisor makes it a point to be present at this hour; he eats his lunch with the boys, and finds in this way an excellent opportunity for gaining their confidence and friendship. This is one of the important features.

Name Johnson, George

Department C.I. Turning

| Grade | A 90-100 | B 80-90 | C 70-80 | D 60-70 | E Below 60 |
|---|---|---|---|---|---|
| Interest | Enthusiastic | Very Interested | Interested | Lacks Interest | Disinterested |
| Application | Very Industrious | Good Worker | Steady | Fair | Lazy |
| Aptitude | Very Quick to Learn | Apt | Learns Readily | Slow to Learn | Dense |
| Reliability | Trustworthy | Reliable | Satisfactory | Irregular | Unreliable |
| Confidence | Excellent | Self-Reliant | Confident | Lacks Confidence | Timid |
| Conduct | Exceptional | Very Gentlemanly | Well Behaved | Troublesome | Unsatisfactory |
| Accuracy | Exceptionally Accurate | Accurate | Average | Inaccurate | Careless |
| Speed | Very Rapid | Rapid | Good | Slow | Very Slow |
| Knowledge of Work | Excellent | Very Good | Good | Fair | Poor |
| Initiative | Excellent | Very Good | Good | Fair | Poor |
| Attendance | Excellent | Very Good | Good | Fair | Poor |

Interest B, Application B, Aptitude C, Reliability B, Confidence C, Conduct B, Accuracy C, Speed C', Knowledge of work C, Initiative B, Attendance A

Remarks: Doing very well for new boy

Dated 2-11-15 Signed W.H. Mowedette

PLEASE FILL OUT AND RETURN PROMPTLY

Fig. 3. Foreman's Report on Work and Character of Apprentice

### Qualifications for Admission to Apprenticeship Course

Any boy over sixteen, normally developed, who has successfully finished the regular grammar school course, is eligible to enter the apprenticeship course. Sufficient physical maturity is required, and if a regular grammar school education is lacking, the boy will not be accepted unless he can show evidence of some other qualifications that are especially desirable. An effort is made to obtain boys who have had some high-school education, and allowance is made in the length of the apprenticeship course of those who have completed a full high-school course and who can give a testimonial as to scholarship. This allowance varies from six months to one year, depending upon the nature of the course pursued while in school. The regular apprenticeship course is four years, but young men of twenty-one are given a three-year apprenticeship, as their age usually makes it possible for them to acquire an equivalent training in that time; they are, as a rule, more advanced both as regards intelligence and application to their work. In spite of the high requirements for admission, the company has had no difficulty in maintaining the number of apprentices in their works between 130 and 140, which is considered a normal quota at the present time, but this is being gradually increased. There is also a constant waiting list of apprentices. It is of interest to note that the boys entering the apprenticeship course are not drawn from the immediate locality only, but many come from distant states at the advice of friends or relatives, and the apprenticeship course in that way may be looked upon as a school of national importance.

### Selection of the Best Material

When a boy applies for an apprenticeship, he is asked to fill out an application blank, giving, among other things, the name of his parent or guardian, his parent's or guardian's occupation, his own age, height, weight and nationality, together with the nationality of his parents. The form also includes questions as to whether he uses tobacco or

Name Johnson, George M.

Trade Machinist Years to serve 4

Began apprenticeship Jan. 11, 1915

Papers signed April 15, 1915

Completed apprenticeship

| Grade | A 90-100 | B 80-90 | C 70-80 | D 60-70 | E Below 60 |
|---|---|---|---|---|---|
| Interest | Enthusiastic | Very Interested | Interested | Lacks Interest | Disinterested |
| Application | Very Industrious | Good Worker | Steady | Fair | Lazy |
| Aptitude | Very Quick to Learn | Apt | Learns Readily | Slow to Learn | Dense |
| Reliability | Trustworthy | Reliable | Satisfactory | Irregular | Unreliable |
| Confidence | Excellent | Self-Reliant | Confident | Lacks Confidence | Timid |
| Conduct | Exceptional | Very Gentlemanly | Well Behaved | Troublesome | Unsatisfactory |
| Accuracy | Exceptionally Accurate | Accurate | Average | Inaccurate | Careless |
| Speed | Very Rapid | Rapid | Good | Slow | Very Slow |
| Knowledge of Work | Excellent | Very Good | Good | Fair | Poor |
| Initiative | Excellent | Very Good | Good | Fair | Poor |
| Attendance | Excellent | Very Good | Good | Fair | Poor |

**Shop Record**

| Department Number | Date Entered | Date of Report | Interest | Application | Aptitude | Reliability | Confidence | Conduct | Accuracy | Speed | Knowledge of Work | Initiative | Attendance | Hours in Department | Total Hours |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7 | 1-11 | 2-11 (1) | B | B | C | B | C | B | C | C | C | B | A | | |
| | | 3-11 | B | C | C | B | C | B | C | C | C | C | B | | |
| | | 4-12 | B | B | B | B | B | B | C | B | C | B | A | 1402½ | |
| 5 | 6-21 | 9-25 | C | B | C | B | C | B | C | C | C | C | B | 1565 | |
| 32 | 1-17 (2) | 5-23 | B | A | B | A | B | A | B | B | B | B | A | 1597½ | |
| 2 | 9-18 | | | | | | | | | | | | | | |

**School Record**

| Date of Report | Mathematics | Science | Drawing | Shop Practice | Note Book | Industrial Hist. | Commercial Geog. | Civics | Absences | Times Tardy | Conduct |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1-16 | No marks given | | | | | | | | | | |
| 4-12 | B | C | C | C | B | | | | 1 | 1 | B |
| 6-28 | B | C+ | C | C | B | | | | " | " | B |
| 11-8 | A | B | C+ | B | C+ | | | | " | " | B |
| 1-17 | B+ | B- | C+ | B | B | | | | 1 | " | B |
| 4-17 | A | B | B-C | | B | | | | " | " | B |

Remarks: (1) Doing very well for new boy (2) Completed lot #: 12-29-15

B.30 AR

Fig. 4. Record kept by Supervisor of Apprentices, covering all Reports made by Shop Foremen and Class-room Instructors

Fig. 5. Boys in their Third and Fourth Year working in Tool-room

Fig. 6. Apprentices in their Third and Fourth Year engaged in Toolmaking

intoxicating liquors, and as to whether he is naturally of robust health. Questions relating to education have then to be answered, and the reason given for seeking an apprenticeship, and also for selecting the Pratt & Whitney Co. as a place where to serve the apprenticeship. If the boy has had any previous business or mechanical experience, this is also noted on the application blank. When a boy inquires at the employment office concerning an apprenticeship, he is asked to fill out the application blank, and if he appears to be especially desirable, he is interviewed by the supervisor of apprentices on his first visit. If not, his application is filed and he is told to call again at some later date. Asking for a second visit has proved an effective method of eliminating those boys who are not in earnest. When the boy finally has been accepted, he is assigned to a manufacturing department where he is required to serve a trial period of three months.

### The Trial Period

At the end of each month of the trial period, the foreman of the department to which the boy is assigned submits a written report of the boy's progress and general behavior. These reports are made on the special blanks shown in Fig. 3. Thus the supervisor is kept constantly informed as to the boy's ability and progress. The report contains information on the following subjects: interest, application, aptitude, reliability, confidence, conduct, accuracy, speed, knowledge of work, initiative and attendance, with a line for any special remarks. If the reports submitted during the trial period are satisfactory, the apprenticeship agreement between the company and the boy is signed. If the reports are not satisfactory and it seems evident that the boy is not fitted for the trade, he is frankly advised to seek some other line of work. After the trial period, similar reports are made at about six months' intervals, by the foremen in the departments where the boy works. Should the boy remain less than six months in any one department, a report is, of course, submitted by this department for the period of time that he has worked there. These reports are all copied onto the record sheet shown in Fig. 4, where the shop records as well as the class-room records of the boy, covering his whole apprenticeship period, are entered. On the back of this record the statements given in the application blank are entered, so that this card constitutes a complete record for each boy.

### Shop Training

The shop training of the apprentices is obtained in the regular manufacturing departments of the company's plant. To insure an all-around experience, the boys are changed from one department to another as often as their progress warrants. The minimum stay in one department is usually six months, and as the boy advances in his apprenticeship, his stay in each department is usually lengthened, as he is then better able to profit by a thorough training in any one specific line. The following outline indicates the way in which an apprenticeship may be distributed throughout the plant: six months, cast iron turning department; six months, milling department; six months, steel turning department; six months, assembling department; six months, grinding department; nine months, planing department; nine months, tool-room. Owing to a number of variable conditions and also to the variation in the ability of the apprentices, no definite schedule is laid out, but the one given represents an average case.

In the shop the boys are directly responsible to the foreman of the department, who usually assigns them to a subforeman or gang boss, who, in turn, selects their work and gives them the necessary instructions. As mentioned, written reports are given to the supervisor as to the boys' progress and general behavior, and the supervisor seeks by frequent visits to the boys, while at their work, to keep closely in touch with them. An effort is made to impress the boys with the

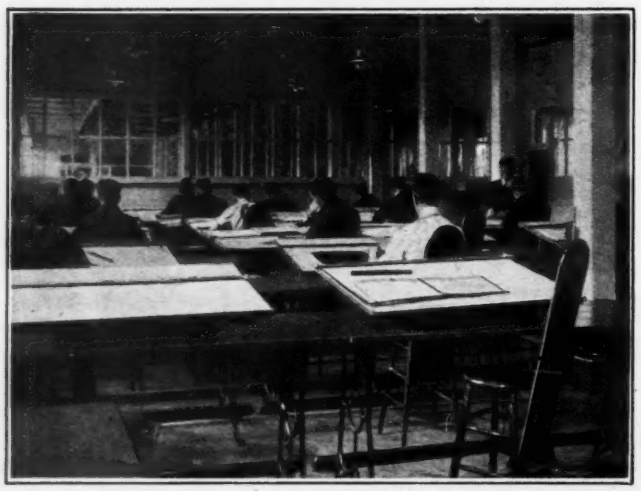


Fig. 7. Apprentices taking a Lesson in Drawing—The Course is especially intended to teach the Reading of Working Drawings

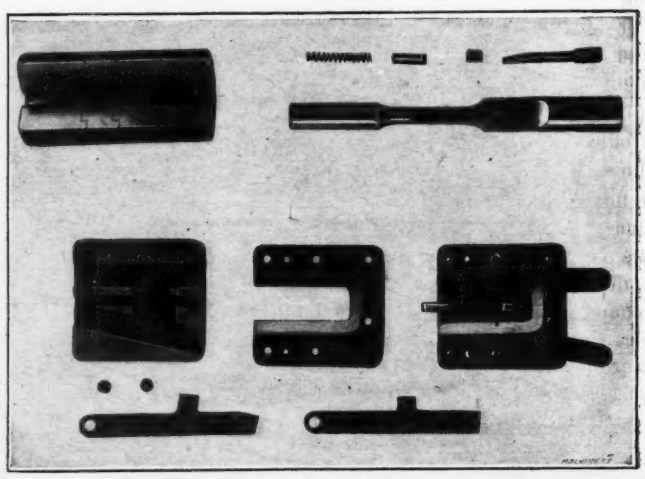
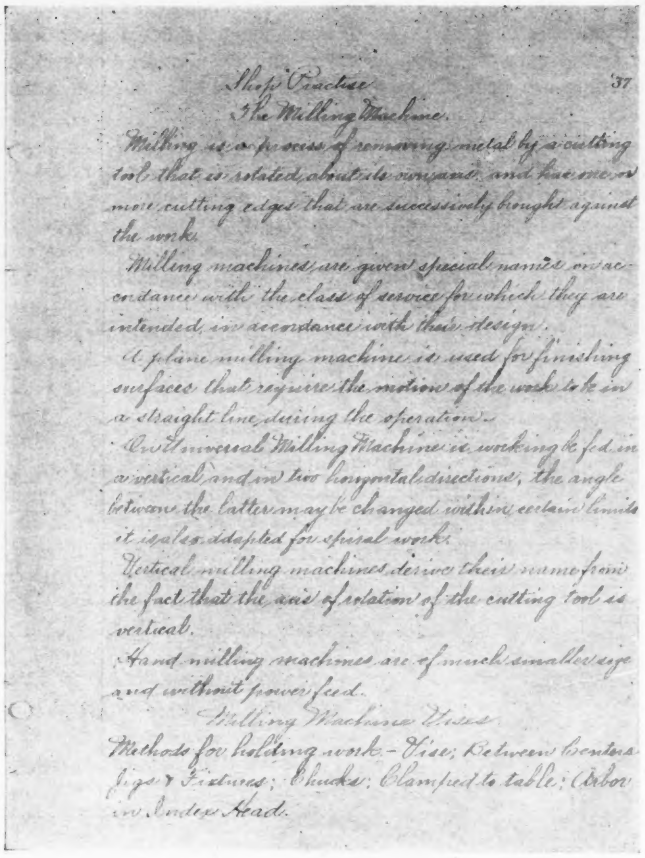


Fig. 8. Gages and Tools—Commercial Products—made by Apprentices in the Third and Fourth Year of the Course



Shop Practice 37

The Milling Machine.

Milling is a process of removing metal by a cutting tool that is rotated about its own axis, and has one or more cutting edges that are successively brought against the work.

Milling machines are given special names in accordance with the class of service for which they are intended, in accordance with their design.

A plane milling machine is used for finishing surfaces that require the motion of the work to be in a straight line during the operation.

A universal Milling Machine is working be fed in a vertical, and in two horizontal directions, the angle between the latter may be changed within certain limits it is also adapted for spiral work.

Vertical milling machines derive their name from the fact that the axis of rotation of the cutting tool is vertical.

Hand milling machines are of much smaller size and without power feed.

Milling Machine Vises

Methods for holding work - Vise; Between centers Jigs & Fixtures; Chucks; Clamped to table; Arbor in Index Head.

Fig. 9. Sheet from One of the Note-books kept by an Apprentice

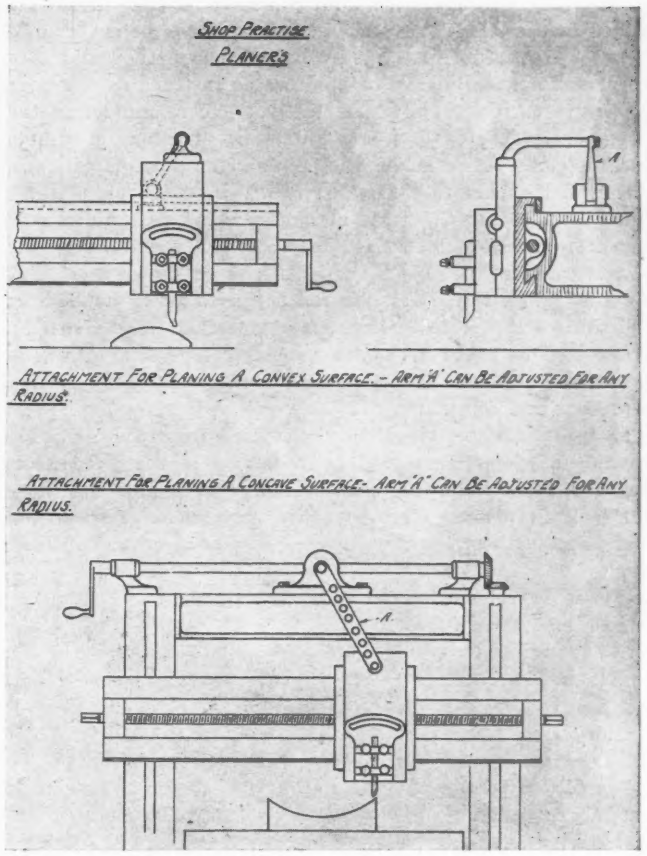

SHOP PRACTICE
PLANER'S
ATTACHMENT FOR PLANING A CONVEX SURFACE. - ARM 'A' CAN BE ADJUSTED FOR ANY RADIUS.
ATTACHMENT FOR PLANING A CONCAVE SURFACE. - ARM 'A' CAN BE ADJUSTED FOR ANY RADIUS.
A

Fig. 10. Another Sheet from Apprentice's Note-book on Shop Practice

fact that their progress depends on their effort, and that the grade of work they receive is according to the ability they have shown. Thus, while no boy is accepted as a toolmaker apprentice, every boy is given the promise that if he shows the necessary skill and aptitude he will be given tool-room work before the termination of his apprenticeship. An example of the work done by tool-room apprentices is shown in Fig. 8. At present a special department is equipped in the company's plant for the manufacture of miscellaneous machine parts, such as vises, turret tools, oil pumps, etc. While operating on a strictly manufacturing basis, most of the work in this department is done by apprentices who begin their training here and are later transferred to the other departments as their skill warrants. Here the boys are under more direct supervision than in the regular manufacturing departments. When a boy in some other department fails to make the progress expected of him, he is brought back into this department, where he can be given the special assistance he requires.

### Class-room Instruction

To supplement the shop work, the apprentices are given class-room instruction four hours each week. In order to interfere as little as possible with their work in the manufacturing departments, these four hours are included in one session, the hours for the different classes being from 8 to 12, or from 1 to 5. The classes consist of from eighteen to twenty boys each. The course of study is divided into four main headings, mathematics, drawing, science and theory of shop practice, the object being to impart as much of an understanding of the principles that underlie all shop work as is possible in the time devoted to this study. In addition to these subjects, a brief course is given in industrial history, commercial geography and civics.

### Extent of Course

Considerable time is spent in a review of arithmetic. The boys are also taught how to use formulas given in handbooks, and to solve simple shop problems involving elementary geometry and the trigonometry of the right-angled triangle. The problems are selected from the regular shop work, which arouses great interest, as the boy can see the direct application of his mathematical studies to his work.

In drawing, the main object is to teach the boys to read blueprints and make simple sketches. During the first year,

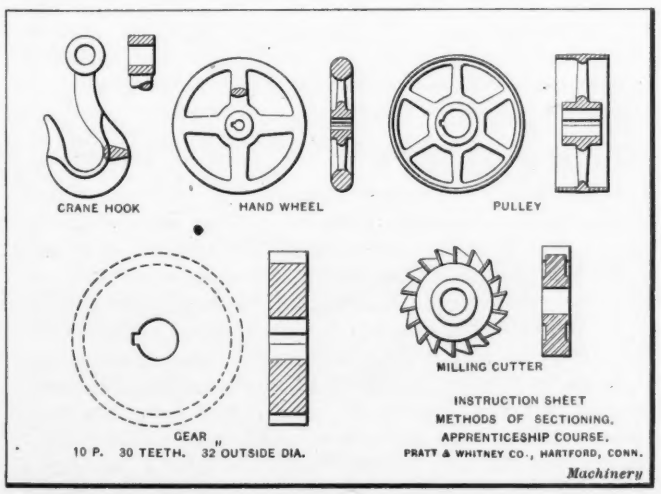



Fig. 11. Sample of Instruction Sheet used in Mechanical Drawing Course

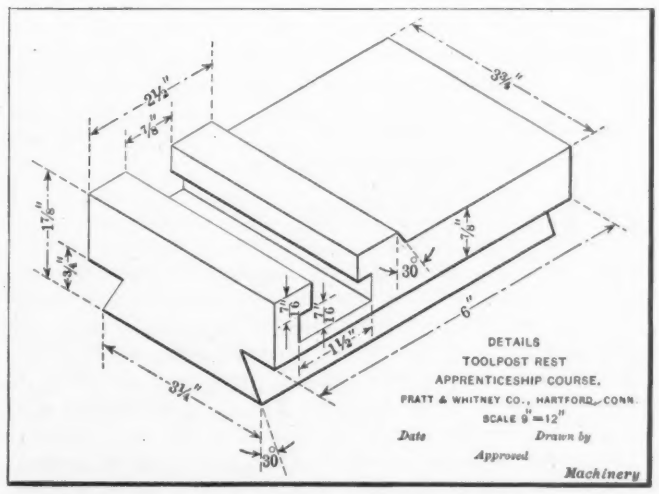



Fig. 12. Example of Isometric Projection View from which Boys work

the boys begin by making simple plates of letters. These are started in the class-room and finished at home, being brought back for inspection and correction. It has been found that the plates of lettering are of great value in teaching the boys to observe correctly and work neatly. The remainder of the first year is devoted to making working drawings of simple machine parts. As a model, the boy is given an isometric projection of the part (see Fig. 12) rather than the piece itself. It has been found that this method makes greater demands upon his powers to visualize the piece and select the proper views to present the object. The illustration shown in Fig. 12 is not a picture of the drawing the boy is to make, but simply a picture of the piece in isometric projection from which he is expected to make a regular mechanical drawing showing two or more views, according to the number that are required to present and dimension the piece properly. If a boy seems to have difficulty in visualizing the piece from the isometric drawing, a projection screen and a model of the piece itself are substituted in order to show him clearly how the piece will look in ordinary orthographic projection. During the later years of the apprentice course, most of the drawing work consists of sketching simple tools and machines, and making finished drawings from them. Throughout the course the standards, rules and drafting-room practice employed in the company's drafting-room are adhered to.

The course in science is devoted, during the first year, to the study of the first principles of mechanics and their application in simple machines. In the second year the elementary principles of heat, light, sound and electricity are covered. Such subjects as light and sound are dismissed with one or two brief lectures each. The subject of heat, however, is given more consideration, as there is an opportunity in this case to point out the effect of heat in connection with shrink fits, hot bearings, and other shop applications. In electricity, special attention is given to different types of motors, their characteristics and advantages, magnetic chucks and other electrical shop tools. In the third year a brief outline of chemistry is given, followed by a study of the various metals used in the machine shop, and the second half of the third year is devoted to the study of personal hygiene and public sanitation.

Fig. 13. Basket Ball Team—Athletics and Healthy Social Activities are encouraged

### Theory of Shop Practice

In the theory of shop practice, explanation of the construction and operation of the various machine tools is given in more detail than would be possible during the regular working hours in the shop. During the first year the lathe serves as the basis of study. Beginning with the preparation of the stock, the boys are taught how to locate and form the centers; how to hold the work in the lathe; how to grind and set the tool; and how to select the proper speeds and feeds. Straight and taper turning, chuck and faceplate work, boring, thread cutting and special forms of turning are then treated in their regular order. Most of this instruction is given in the class-room and illustrated by sketches on the blackboard, but when desirable the class is taken to some machine department and the actual operations are observed and explained. Sometimes machines are brought into the class-room for more detailed study.

During the second year, a similar study is made of drilling machines, shapers, planers and milling machines, and in the third year grinding machines, small tools, hand tools and operations such as scraping and fitting are studied. During the fourth year a general review is made of all shop work, and the more difficult problems met with in tool-room work are introduced. At various times special attention is also given to such machines of the company's manufacture as the thread milling machine, the automatic milling machine, the vertical shaper, the spline milling machine, etc.

### Instruction in General Subjects

During the last year of the apprentice course a deviation is made from the purely mechanical instruction of the first three years, and a series of lectures covering industrial history, commercial geography and civics is introduced. These subjects are intended to broaden the boy's conception both of his work and his relation to the community of which he is a part. In the industrial history course he is told of the development of the machine industry, the problems that confronted early mechanics, and, finally, the important part played by the company with which he is serving his apprenticeship in the industrial history of his country and the world. In commercial geography, he is given an understanding of the sources of raw materials and the markets of the world for finished products, and is given an idea of the problems that have to be solved in obtaining and transporting materials and products from one part of the world to another.

In civics, a brief outline is given of the nation's development. The principles of the structure of government—especially of municipalities and state government—are explained. Special stress is laid upon the dependence of a democracy upon the high standing of each individual's civic spirit.

### Instructors and Division of Time for Different Studies

The instruction in general subjects, mathematics, science, etc., is given by the supervisor, but a large part of the instruction in the theory of shop practice is given by shop men who have been selected because of their personal skill and ability to impart the knowledge of their particular work to others. This idea of enlisting among the corps of instructors a number of shop men, especially sub-foremen, gang bosses, etc., tends to enlarge the circle of men who are personally interested in the welfare of the boys, and this, in turn, is of assistance to the boys in their shop training. This method of instructing the boys in shop practice creates a connecting link between the shop and class-room instruction, and is one of the most valuable features of the apprenticeship course.

The four hours devoted to class-room studies weekly are divided among the different subjects as follows: mathematics, one hour; drawing, one and one-half hour; theory of shop practice, one hour; and science, one-half hour. This time schedule is not rigidly adhered to. Whenever special conditions come up, making it desirable to devote either more or less time to any one subject, the supervisor uses his judgment in this respect. The time division given above, however, indicates approximately the length of time that has been found necessary to obtain the desired results.

### Method of Instruction

No regular text-books are used for any of the courses. Instruction sheets have been prepared for certain subjects, especially for mechanical drawing, but the main part of all instruction is given by means of lectures with the assistance of the blackboard. In order to make sure that the boys get full benefit from this instruction, and in order to provide them with a permanent record of their work, they are required to keep a note-book which covers all their school work and which is submitted from time to time to the supervisor for criticism and inspection. In order to give added incentive for thoroughness, care and accuracy, a prize is awarded each year for the best note-books. The work on these books is done at home in the boys' own time. Some of the boys take great interest in this work and their note-books really become handbooks of shop practice, showing considerable ability. Sample sheets from one boy's note-book are shown in Figs. 9 and 10.

### Compensation

The boys are taught to look upon their apprenticeship as a period of training and are made to understand that the apprenticeship course is a school in which their interest must be centered upon what they learn and not upon what they earn. Nevertheless, it must be recognized by anyone who would institute a successful apprenticeship system that the rates paid must be sufficiently high to make the boys self-supporting from the start; otherwise the system would be doomed to failure, as most of the boys could not afford to take a four-year course of this kind unless they could pay their way. There are four classes of apprenticeships at the present time instituted by the Pratt & Whitney Co.: A machinist, patternmaker, molder, and coremaker apprenticeship. In the four-year machinist apprenticeship, the rates are for each of the four years, respectively, 14, 15, 17 and 18 cents per hour, and for the three-year apprenticeship, 15, 17 and 18 cents per hour. In the patternmaker apprenticeship, comprising four years, the rates are the same as for machinists. The molder apprenticeship comprises three years, 20 cents per hour being paid for the first three months, 22 cents per hour for the remainder of the first year, 25 cents for the second year and 27 cents for the third year. The coremaker apprentices receive 14, 17 and 19 cents, respectively, for each of the three years of the apprenticeship. In each case, a bonus of $100 is paid to the apprentice upon the successful completion of his apprenticeship. The reason for the materially higher rates of molder apprentices is that, as a rule, these apprentices must be older or stronger than those for the other course, on account of the nature of the work; also, the work is less agreeable, and a special inducement is given in the form of higher wages during the apprenticeship years.

The boys often earn much higher wages than those indicated by the rates given, as they are enabled to increase their earnings both by working overtime and by means of piecework. It is also possible for every boy to obtain a higher rate if his record is exceptionally good. Every boy that averages a certain mark for one year both in the shop and the class-room work is given an increase of one cent per hour as long as he maintains this mark. If his rating is still higher, he is given a two-cent increase under the same conditions. The boy thus recognizes early in his apprenticeship that his earning power is dependent upon his own efforts and skill.

### Social Activities

In order to add an interest and to maintain a feeling of fellowship outside of the working hours, athletics have been introduced as a feature of the apprenticeship system. Teams have been organized and games are played, schools being chosen as opponents as far as possible. Places on the teams are dependent on shop and class-room records. There are no "athletic scholarships," and any boy that seeks recognition in these athletic activities recognizes that he can gain it only by meeting the requirements of the shop and class-room. All this tends to create a spirit of interest, good fellowship and loyalty, the shop being looked upon not merely as a place to work, but also as a school in which the young man is fitting himself for his life work.

### Conclusion

It is freely admitted that the object of the apprenticeship system is to train skilled mechanics for the Pratt & Whitney Co., and every effort is made to induce the boys to stay with the company upon the completion of their apprenticeship. Most of them, in fact, do stay, and the foremen of the different departments are instructed to pay the graduated apprentice the market rate of wages commensurate with his proved ability. To determine his ability the supervisor and foreman consult together, and in this way it has been possible to pay wages attractive enough to hold a large number of the boys whom the company has trained. Many of those who leave to go elsewhere for new experience return after a short time to work for the company where they obtained their training.

Those who are of the opinion that an apprenticeship system is out of date or who are skeptical of its effectiveness would do well to study the modernized methods of apprenticeship training that have been put into effect by the Pratt & Whitney Co., and they would be well repaid for making a personal visit and observing the methods used by the company. The importance of proper training of apprentices is one of the greatest problems of the mechanical industries at present, and it is to be hoped that the example set by one of the foremost machine-tool builders in the country will be followed by others, so that, in years to come, there will not need to be the present lack of skilled mechanics. This article has been published not merely with a view to presenting what the Pratt & Whitney Co. has done to develop a modern apprenticeship system, but also to stimulate others and show what can be done in this respect, the methods that should be employed, and the results that are likely to follow.

* * *

## COMBINATIONS FOR EXPORT TRADE

The Webb bill now pending in Congress is intended to permit combinations of American manufacturers for the sole purpose of promoting foreign trade. The object of forming such combinations is to enable American manufacturers to transact foreign business on a more efficient basis and to cope more effectively with foreign combinations, which are said to be adverse to domestic interests. It is pointed out that the small American manufacturers producing more than the domestic market will consume and desiring foreign trade, are confronted at the outset by a large expense and delayed returns incident to creating and maintaining a selling agency abroad. The Webb bill is designed to permit such manufacturers to cooperate, and not only support a common selling agency, but enter into agreements that would prove mutually beneficial. While it is not clear at present to what extent existing anti-trust laws would prevent such combinations, if made in good faith, it is supposed that American manufacturers are afraid to combine in the interests of foreign trade and that this condition must be remedied if the United States is to secure the full advantage of present opportunities. If this bill becomes a law, the combinations are supposed to be exclusively for facilitating and benefiting export trade without restraining or monopolizing trade within the United States. Some opponents of the bill contend that permission to combine for export trade might result in injury to American consumers and the smaller American manufacturers. This fear is considered groundless by those advocating the passage of the bill in view of the fact that the Federal Trade Commission shall have power to restrain and prevent action by combinations in foreign trade, which react as an undue restraint upon internal commerce.

# DRILL CHUCKS

## PRINCIPLES GOVERNING DESIGN AND METHODS OF OPERATION

BY JOSEPH HORNER[1]

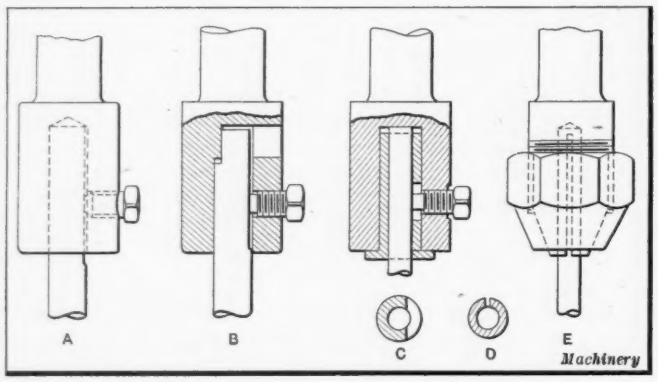



Fig. 1. Simple Types of Drill Chucks

THE scope and functions of a drill chuck are simple in comparison with those of an ordinary lathe chuck. In a drill chuck, a cylindrical shank, plain or grooved, has to be held in alignment and with sufficient firmness to resist slipping under the stress of work. But around this simple requirement a large number of mechanisms have been constructed, and the design is still in the course of evolution, tending to simplification rather than elaboration, as is the case in many kinds of appliances.

Methods of preventing slippage, which wastes time and damages shanks, must not interfere with the loosening of the tool. A chuck, therefore, should be constructed so that hard gripping of the drill will not result in jamming. Although many chucks are self-tightening and hold more firmly as the drill tends to slip, they are not necessarily difficult to unlock. Hardening of the working parts makes unlocking easier, for unhardened steel surfaces are compressed out of shape or torn, with consequent seizing of mating parts. Slippage is not so trifling a matter as it may appear, especially with regard to its effect on the shanks. Their tearing up and consequent deformation soon affects the truth of running, and although this is not such a vital matter in plain drilling, it is of great importance in the case of drills and tools used with jigs, and in operating counterboring, facing and other tools which are supposed to run true when secured in a chuck. Their irregular running may not at first affect results, but side pressure will eventually wear the pilots and produce accentuated errors. The same thing happens with ordinary drills of twist or straight flute form; if running eccentrically, they wear on one side and true drilling becomes impossible. Any chuck that grips a shank rigidly should run it truly, so recent practice favors the principle of a floating hold, by which all difficulties of this kind are eliminated, and lack of accuracy in the chuck mounting or spindle running has no effect on the working. The shank is fitted loosely, although driven in a positive manner, and the point of the tool is at liberty to wobble. It ceases to do so as soon as drilling commences, and the freedom to follow a true rectilinear path produces better work. Also, the drills are not so likely to wear, heat or break. The floating drive is of particular value in such operations as reaming, counterboring and countersinking, tapping, etc., and in connection with jigs, especially those employing short, stiff shanks.

The necessity for frequent changes of tools, brought about by the quantity of repetition work now done and by the fact that jigs are so extensively used, has made it necessary to discard some of the older chucks, because they are slow in loosening and tightening. While very good for holding shanks during a considerable period, they are too wasteful of time in handling the class of work just specified. If they are employed, the time consumed in substituting tools is so long in comparison to the running time that the benefits conferred by the use of specialized outfits and jigs are largely lost. The time lost is not only that spent in unlocking the chuck, but also that required to stop the rotation of the spindle and to start it again. In some classes of work it is necessary to use a dozen or more different tools in quick succession. For this reason, a chuck that can be released and regripped while the spindle is running at full speed would mean an immense increase in the output, and the trend of the latest designs is toward the attainment of this end. The cost of the tools is lessened by using collets or bushings, so as to adapt various sizes of shanks to one chuck.

The application of a chuck to a drilling-machine spindle is an alternative to holding shanks direct in the spindle aperture, and is really only a convenience to enable various tools to be substituted quickly. When the spindle only is used, the hole has either parallel or tapering sides, the latter being preferred. Many machines, particularly the lighter classes used by blacksmiths and small shops, have standard size holes with parallel sides in which the shanks are secured by set-screws of the plain or socket style. Drills with uniform shanks to fit these machines are furnished by the makers, and by using sockets, drills with smaller or larger shanks may be driven. This practice is suitable for the class of users concerned, but it does not meet regular workshop conditions so well. Truth of running is likely to become affected in time, the expense of drills with the uniform diameter shanks, especially the smaller sizes, becomes quite heavy, and there is no proper means of holding special drills or tools. Hence, a chuck with movable jaws that will grip any tool soon repays its cost.

When standard tapered holes are used in the spindles, the tools do not work out of truth, as in the case of a hole with parallel sides, and the set-screw, which is a clumsy device, is abolished. Its place is taken by the tang, which affords a positive drive when such is necessary. Besides, various sizes of shanks may be used by the employment of sockets and sleeves. This device does not provide a rapid means of changing drills, and is chiefly useful for medium and large size machines. In the small machines, the tapered hole is retained, and used as a medium for the fitting of a chuck; the latter has its body prolonged into a taper shank or has a shank fitted in a hole.

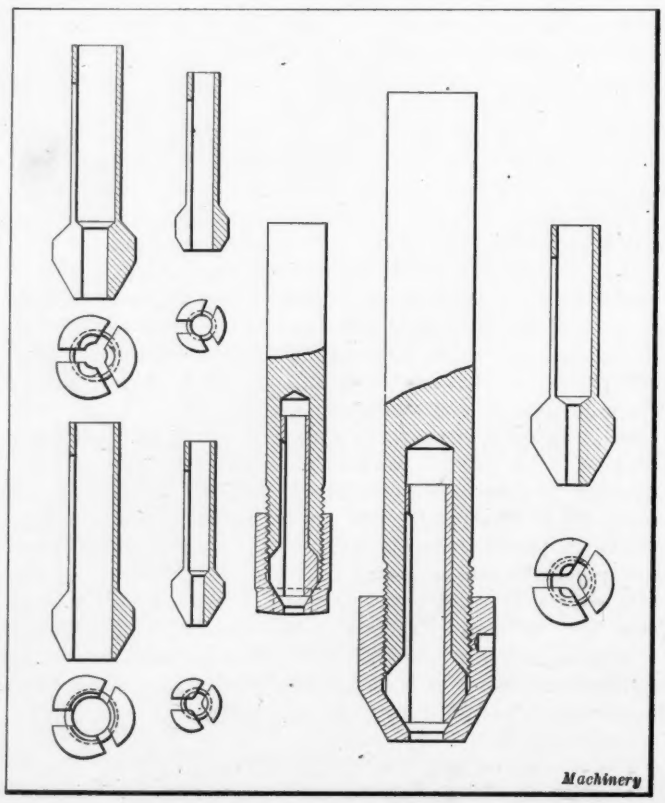



Fig. 2. Collet Chucks for Small Drills

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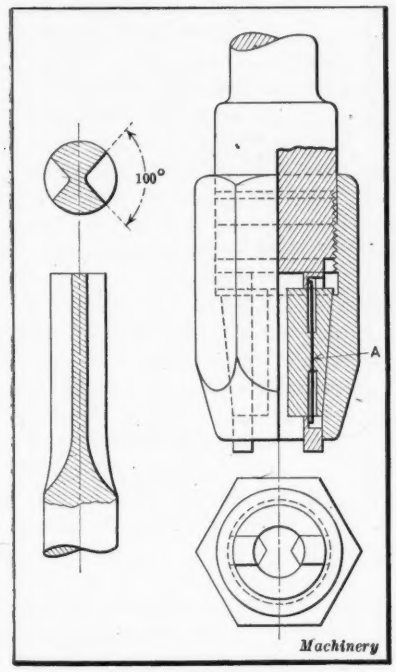


Fig. 3. Drill Chuck for Graham Grooved Shank

### Early Chuck Designs

The earliest designs of chucks in which the shanks were held with a set-screw are still used in the rougher kinds of machines. The shank shown at *A*, Fig. 1, has a flat on which the set-screw bears and acts as a driver. The method of making a flat on the tail of the shank to catch against a flat in the chuck was soon developed, so that a positive drive independent of the set-screw resulted. At *B* is shown an example of this design. The set-screw is needed only to keep the drill from falling out of the chuck.

A collet or bushing may be fastened in place by letting the screw press on the shank, through a slot cut in the bushing, as at *C*, or by splitting through at one side, as at *D*. The latter device preserves the shank from the marring action of the screw tip. A neater method is to close the bushing by cone pressure, as in collet chucks. For single sizes, the chuck body can be split, threaded and coned so that the tightening of the nut binds the shank; this form is shown at *E*. Interchangeable collets should be formed with long stems, as illustrated in Fig. 2, which shows several sizes made by the Trump Bros. Machine Co.; these will hold drills ranging from 0 to ⅜ inch in diameter. The chuck shank is either held in a larger chuck or is turned on a taper to fit a spindle. The utilization of collets or liners to adapt one chuck for different diameters of shanks is not so common as formerly, because the same effect can be attained more simply and with less trouble by an adjustable jaw chuck. The liners are a source of trouble on account of dirt and must be wiped before they are placed in position; in addition, they wear in course of time, so that the shank is pushed to one side and runs eccentrically.

In the chuck made by the National Twist Drill & Tool Co. of Detroit, Mich., a coned nut is used to close in the sleeve fitting inside the body. There is a tang on the tail of the sleeve to engage with a slot in the body, giving a positive drive, and the sleeve is shaped internally to a Morse taper, or it has parallel sides and prongs to catch and drive a Graham grooved shank. Another design of chuck intended for these shanks is manufactured by the Cleveland Twist Drill Co., and is shown in Fig. 3. The jaws that clamp the V-grooves are fitted into slots in the chuck body and are forced inward by the turning of the nut, which has parallel bearings at the front and rear to preserve alignment. A flat spring *A* presses the jaw outward to release the shank when the nut is slacked off.

### Scroll and Geared Chucks

The introduction of regular jaws enables a chuck to hold a certain range of diameters; the methods of actuating the jaws are varied. One of the earliest ideas was to follow the scroll design, and some chucks are still made on this principle, particularly those intended for use in the lathe to hold rods as well as drills. The mechanism is similar to that of an ordinary scroll chuck, the jaws being beveled off on the outside to give a clear view and to avoid risk of injury to the operator. Light chucks are worked by rotating a knurled ring, which has holes to give an extra grip when required. More powerful designs embody a gear scroll mechanism, with bevel or worm-gears turned by a key.

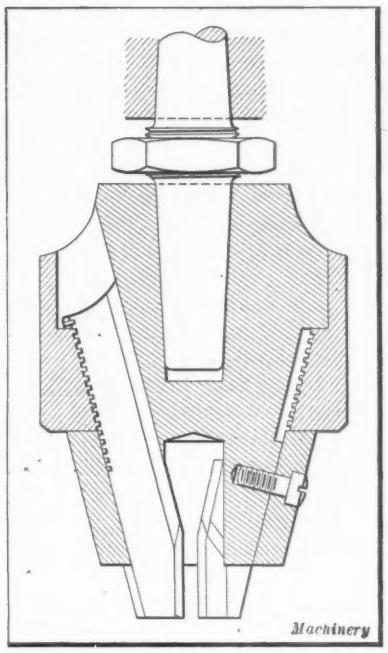


Fig. 4. Three-jaw Scroll Chuck operated by Knurled Sleeve

A more convenient adaptation of the scroll principle is that of cutting the scroll inside a coned ring and guiding the jaws in grooves at the same angle. This arrangement results in a more compact form of body, and since the jaws do not travel radially, as in the flat scroll device just mentioned, the nose formation of the chuck can be made more pointed; this is a handy feature in the case of small drills and fine work. The threads of the scroll are often square; but a buttress section is preferred by some as being better adapted to resist the direction of pressure. Fig. 4 shows the Skinner chuck, with square threads cut inside the knurled sleeve, which can be tightened by a spanner wrench. The chuck is made in three sizes, 0 to 7/32 inch, 0 to 11/32 inch, and 0 to 17/32 inch.

The geared chucks afford a more convenient method of operation than rotating a knurled sleeve, because the latter requires the spindle to be held from turning, thus necessitating the use of both hands. By turning the sleeve with a gear and key the necessary twisting action is transferred to a different direction and has no rotative influence upon the spindle. Extra power is also obtained, a more essential feature nowadays than some time ago, when high-speed steel was not in general use. The chuck which is made by the Jacobs Mfg. Co. of Hartford, Conn., shown in Fig. 5, has a bevel pinion formed on the key; this rotates the sleeve and turns the nut, which is made in halves. "Flat-back" models are built without the chamfer at the back of the body, so that the chuck is shortened and lightened and is more suited for use on pneumatic, electric or flexible drill shafts and for other work where the minimum of weight and size is desirable. Especially light chucks are also constructed by turning a large groove around the body and making some other parts thinner.

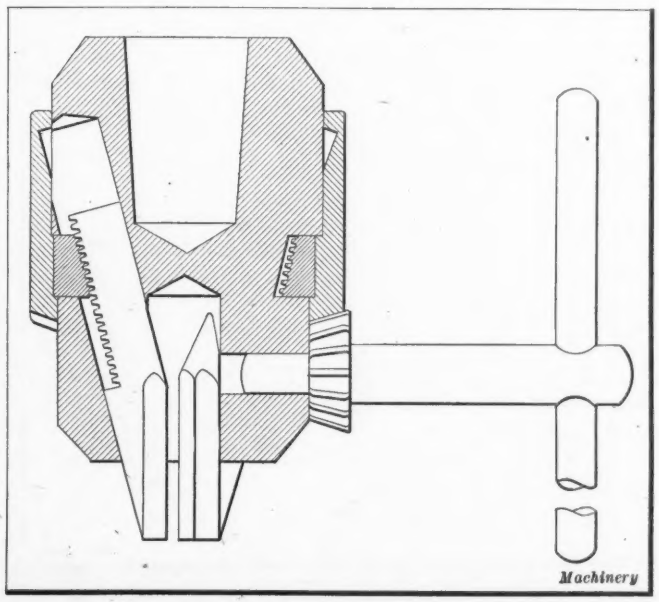


Fig. 5. Geared Chuck

The Almond geared chuck is made somewhat like the chucks that are not geared but are rotated by a knurled sleeve. The teeth are cut direct upon the nut, as in Fig. 6, which is hardened and split in halves. The sleeve only serves as a means of rotating with the fingers and to cover the jaw apertures, and need only be forced on the nut with moderate pressure, as none of the strain of turning with the

key comes upon it. The holes in the body that receive the key stem are provided with hardened bushings to give longer life and maintain alignment of the pinion. In the largest chuck of this series, a capacity from ⅜ to 1 inch diameter is afforded.

In one or two instances, the practice of having the ring of teeth inside has been adopted —as in the Skinner geared chucks—which have pinions laid in pockets. These are covered by the sleeve, except for an opening through which the key is passed to enter into the squared hole in the pinion. The external position is preferred, however, by many, as they claim that this permits a larger pinion and stronger teeth to be utilized.

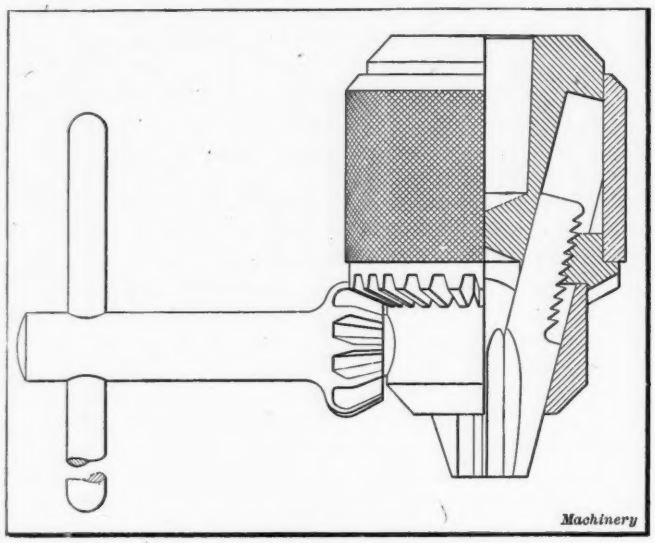


Fig. 6. Geared Chuck with Nut Separate from Sleeve

### Two-jaw Chucks

A popular style of chuck is the two-jaw type actuated by a right- and left-hand square-thread screw. The jaws are notched out to interlock and grip from 0 up to the maximum capacity. The consequent breaking up of the surfaces into a number of separate "bites" assists in obtaining a firm grip for heavy work, a point of importance in high-speed drilling with hard feeding or gripping bars for deep turning or threading cuts. Auxiliary means are taken to strengthen the grip in some designs, such as by the use of side setting-up screws, as in the Westcott device shown in Fig. 7. After the drill has been centered by the jaws and they have been tightened, the side screws are set up, preferably on slight flats made on the shank. Another device is that of a forged steel cap attached to the chuck face with screws that permit a floating movement. A screw in the edge of the cap can be set up to bind the backs of the jaws together and so draw the gripping surfaces more tightly onto the shank. Yet another method is to provide a sort of draw-bolt through the jaws on the opposite side to the right- and left-hand operating screws, the bolt serving to prevent the spreading tendency of the jaws.

The Horton screw chucks are constructed with cylindrical jaws fitting closely in a reamed hole in the body—a neat and compact mode of fit —as shown in Fig. 8. For a positive drive some of these chucks have a pair of flat-ended set-screws tapped through on opposite sides of the body, behind the jaws, the screws being adjusted to engage with the squared end of a tap, drill or other tool. A special type is also built for holding either straight or tapered shanks by means of a duplicate set of jaws at the rear, which are set in accordingly. For a tanged taper shank, the rear set of jaws can be set to give a positive drive to the tang.

Several makes of screw chucks have provision for positive driving through a slotted plate or extra jaws at the top of the regular jaws. Thus a tanged or a squared drill or tap may be positively rotated without any need for tightening the jaws up hard. In the Pratt design the jaw slot is carried up sufficiently to receive a driver plate, Fig. 9, which has a slight amount of play for centering. When the flatted tang is passed up into the slot in the plate the latter catches against the sides of the chuck slot and acts like a lathe dog. Taper-shank drills require an adapter sleeve such as that shown in Fig. 9. In other chucks a pair of plates are attached, either on opposite sides of the bottom of the slot where the jaws stop or on the tops of the jaws. A similar device is sometimes adopted in the three-jaw chucks of the general type shown in Fig. 4, a transverse slot being formed in the body at the back of the jaws. One exception to the usual practice of notching out jaws to interlock is found in the Reid screw chuck, Fig. 10. This arrangement holds from 0 to maximum with three contact points.

### Jaws Closed by Cone Cap

A number of chucks incorporate the principle of three (sometimes two) jaws, loose or pivoted, closed in by a coned cap which is moved longitudinally. Concentric action is obtained, and in many cases the mechanism can be made self-tightening. The chucks used on hand braces are simple examples of the type, consisting of a knurled sleeve pressing on the beveled noses of a pair of jaws. The ends of the latter rest against a V-shaped base, so that the closing in causes them to slide inward and so bear on their whole length on the shank, whether straight or tapered. In some instances, though the cap is used, it does not slide, but the jaws are pushed along by a tail plate, and the coercion of the coned cap produces the closing action.

In another design, made by the Oneida National Chuck Co. of Oneida, N. Y., and shown in Fig. 11, the knurled head of a screw moves the jaws. The head is slotted out to take the tang, thus affording a positive drive when desired. The interlocked jaws shown are for parallel shanks, but a pair for holding tapered shanks can be used. In the latter the inclination of the "bites" from front to back is made to suit any particular Morse taper desired. The positive drive by a tang fitting in the screw head is used also in this case. A more recent design is also made of this chuck with a ball bearing to take the thrust, and the tightening or loosening is effected by a large knurled part of the body behind the jaws. The jaws automatically tighten according to the pressure being exerted on the drill.

The chuck manufactured by the Rich Tool Co. of Chicago, Fig. 12, has jaws closed in by turning the nut, which is coned to match the backs of the jaws, and their tails are shaped to fit in a groove in

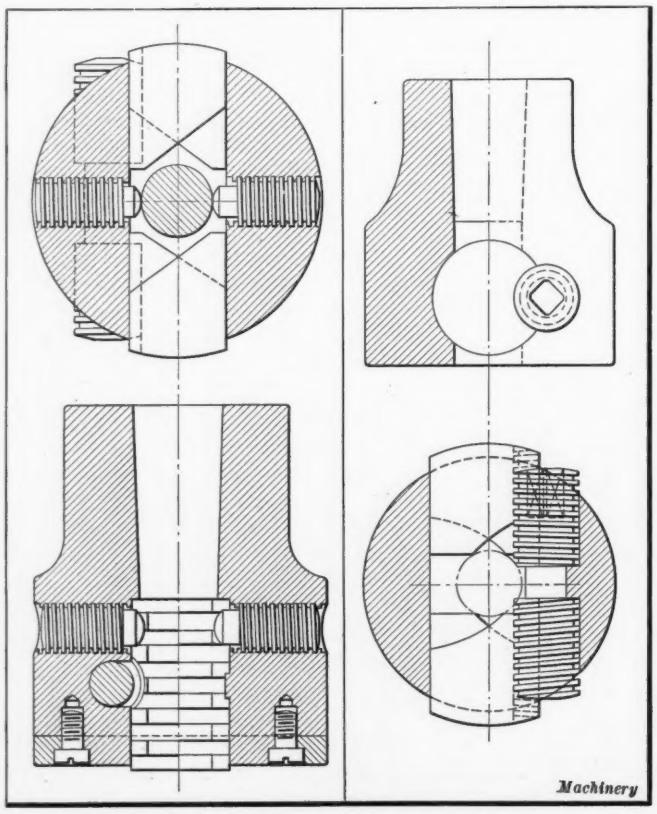


Fig. 7. Westcott Chuck with Side Screws for Extra Grip

Fig. 8. Screw Chuck with Cylindrical Jaws

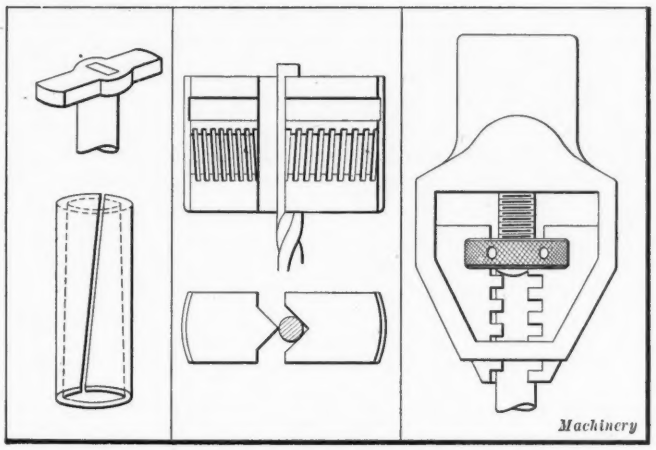


Fig. 9. Driver Plate and Taper Sleeve

Fig. 10. Reid Chuck Jaws with Three Contact Points

Fig. 11. Open Type of Chuck with Positive Drive

the body and prevent misplacement. The Rich drills and reamers with grooved shanks are held in this style of chuck and the jaws clamp an inward taper of the groove in the shank, which prevents the tool pulling out, so that a moderate amount of tightening of the nut suffices.

### Chucks with Anti-friction Bearings

The action of a screw in tightening a coned cap around the jaws of a chuck is objectionable on account of the jamming that occurs, making release difficult. But this objection is easily overcome by introducing an anti-friction bearing consisting of a ring of balls or rollers which do not bind like plain surfaces. There are a good many makes of chucks working on this principle. In the Horton-Morrow chuck, made by the E. Horton & Son Co., of Windsor Locks, Conn., and shown in Fig. 13, the tightening is effected by a large fine-pitch left-hand screw *A*, which automatically tightens in the head *B*, as the drilling pressure increases. The jaws are carried in slots in a releaser *C* driven by a couple of pins engaging in slots in the end of the fine screw *A*. A small amount of play is allowed between the pins and slots so that the releaser possesses a little freedom. The slight rotation of the releaser caused by the opening action brings its coarse-pitch threads *a* into action, and an instant and easy release is obtained. The ball race is shown at *D*.

In the chuck made by Louis Wearden & Guylee, Ltd., of Bradford, Yorkshire, England, Fig. 14, only one screw *A* is used. This has a stout square thread and is formed integrally with the covering cap at the base. The act of screwing *A* into the body *B* raises the jaws *C* and makes them close in by reason of their coned backs pressing against the coned ring *D*. The thrust is received on the race *E* and the hardened washer above it, which prevents the screw from binding. Spring wires *F* and *G* lock the screw *A* and coned ring *D*, while another wire *H* gives the jaws a tendency to spring outward. To release the drill while the chuck is running, the knurled surface of screw *A* is struck sharply with the hand, delivering the blow in the direction of rotation.

An example of a roller-bearing chuck is shown in Fig. 15; this bearing has the advantage of large diameter balls and requires less space. The jaws *A* are propelled by a slotted head *B* into which they are tongued. The head is integral with a coarse-pitch double-thread screw running through the head *C*, and its movement outward or inward contracts or expands the jaws within the hood *D*. The rollers *E* take the thrust between the head *C* and the ring *F* screwed into the body *G*. This chuck is made by the Eclipse Machine Co. of Elmira, N. Y.

The Coit chuck, Fig. 16, made by the Narragansett Machine Co., Providence, R. I., has three jaws propelled by a slotted

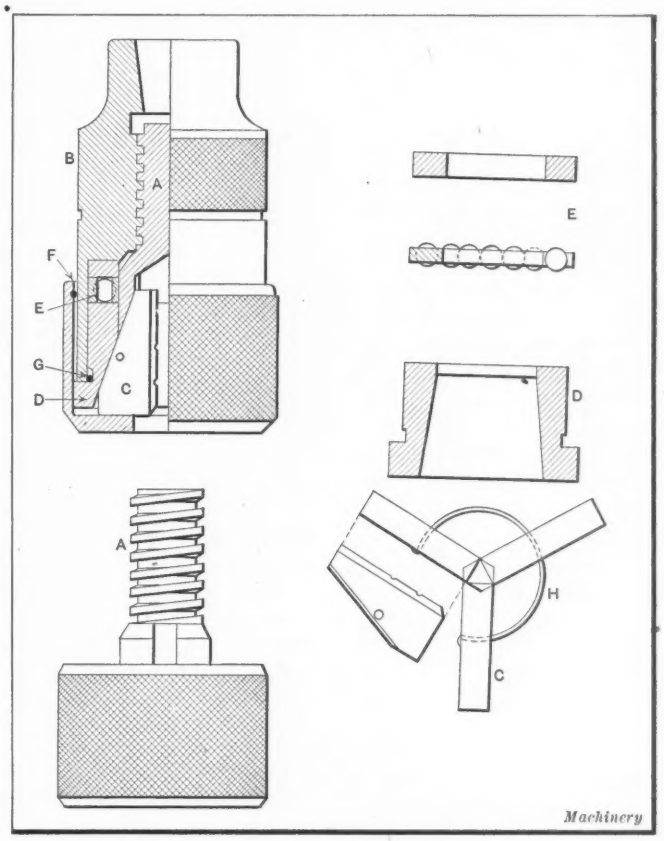


Fig. 14. Three-jaw Automatic Chuck

nut *A*, which runs up and down the screw on the shank *B* according to the way the knurled shell is turned or held by the hand clasp. The jaws, which have disk-shaped tails to catch in the slots in nut *A*, are kept straight by a screw *C* entering a slot in each. Pressure comes against the large flange *D* on the shank, and this is transmitted to the ring of balls above. The chuck automatically tightens as the drilling stress becomes greater.

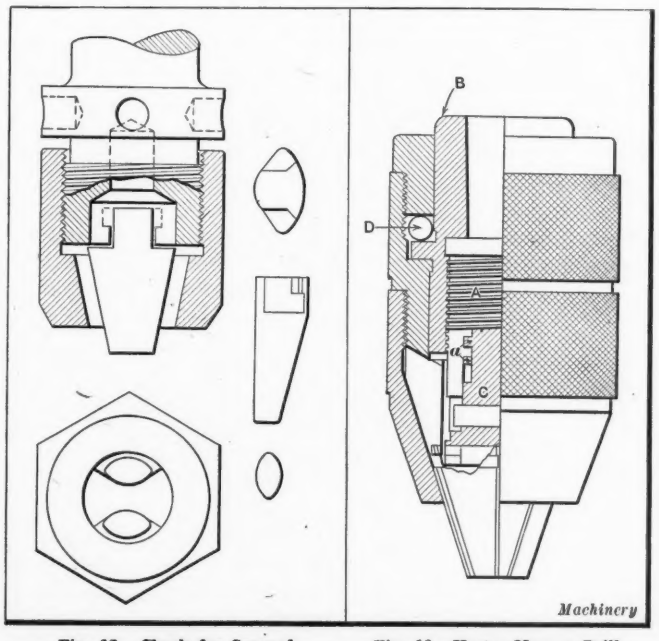


Fig. 12. Chuck for Grooved Shank




Fig. 13. Horton-Morrow Drill Chuck with Ball Bearing

### Self-tightening Chucks

The chucks of another group are built on the self-tightening principle of an eccentric action, which causes the jaws to roll or tilt, and in doing so to bring their surfaces more to the central axis. An attempt of the drill to slip produces extra tightening. Three designs are noticeable, one with round rollers, one with eccentric rollers, and one with lever-like pivoted jaws. In the type with round rollers, of which the Gronkvist, Fig. 17, is an example, the gripping results from the climbing of the rollers up the faces of the three-lobed internal cam. The clutch movement increases with any increase of drilling stress. Normally, the chuck is held closed by a coiled spring and the operator turns the outer knurled sleeve against the direction of rotation of the spindle to open the

jaws for the insertion of a drill. After this has been done, he releases the sleeve, and the jaws automatically grip the shank. As the rollers are quite smooth and hardened, they do not inflict any injury on the shanks.

The Wahlstrom Tool Co.'s chuck, Fig. 19, represents the eccentric roller device, the jaws being so shaped, as shown in the plan, as to roll up the cam faces inside the shell. The spring *A* keeps the shell turned so that the jaws are normally closed. If gripped momentarily by the hand while running, its rotation is stopped and its relation to the body altered so that the jaws open. After the insertion of the drill, the resistance developed makes the jaws roll up the cam faces.

In some chucks eccentric roll jaws are turned positively by teeth inside the shell, each jaw having a couple of teeth meshing with these. A clock spring normally keeps the chuck closed. The arrangement of the jaws is shown in Fig. 18. The principle on which these lever-like pivoted jaws are based is the same as that of certain safety catches for lifts and other mechanisms. The biting of the jaws into the moving element—the drill—forces them to move radially and increases their grip, so by disposing the three (or sometimes four) jaws

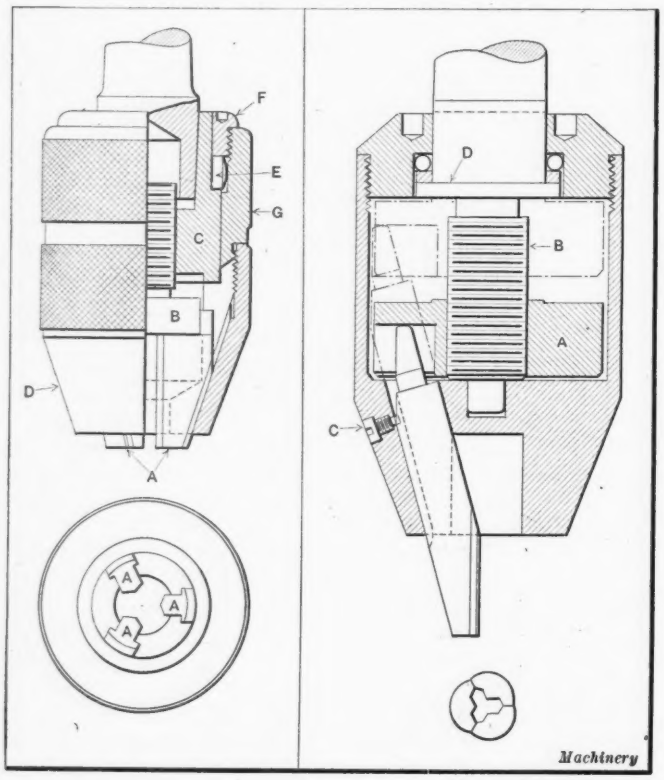


Fig. 15. Roller-bearing Chuck

Fig. 16. Coit Ball-bearing Chuck

equally around the circle a concentric grip is obtained. As usual, a spring is fitted to close the jaws until the operator separates them by arresting the rotation of the knurled sleeve.

### "Pocket" Style of Chucks

During the last three or four years there has been developed what might perhaps be most suitably termed the "pocket" style chuck, because it embodies the principle of a roller, ball, or pad dropping into a pocket and affording a drive to the tool or to its collet. The objection to these chucks is that, as there are no regular jaws to grip various diameters, it is necessary to make the tool shanks to a special formation, or (as must often be done) to employ special collets. These chucks are of the greatest advantage in repetition and jig work, where a set of tools must be utilized in the same spindle in rapid sequence. As a floating drive is given, its degree depending on the fit of the shank in the chuck, considerable advantage is gained in jig work, where a rigidly constrained tool is frequently undesirable on account of the tendency to wear the bushings. Even in ordinary drilling, the floating drive is advantageous, because the drill is enabled to run concentrically after commencing the hole, and no lateral spring arising from a slightly untrue drill or other cause will occur.

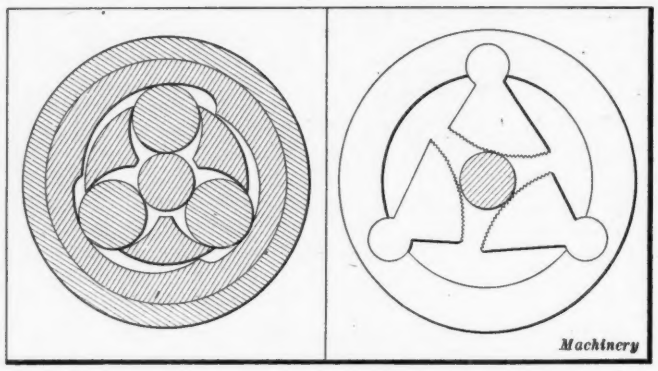


Fig. 17. Principle of Cam and Roller Action in Gronkvist Chuck

Fig. 18. Principle of Pivoted-cam Jaw Action

Examples of each design, the pad, the ball, and the roller, are illustrated. The pad should offer the most powerful drive, but as the pressure is positive, there is apparently not much to choose between its flat line of contact and that of a ball touching at a spot on the diameter.

The chuck made for some years by John W. Barnes of Rock Ferry, Cheshire, England, is employed very largely, and is made either separately in the usual manner or integral with the end of a drilling-machine spindle. The tops of the tools or their collets are dome-shaped and automatically center themselves in the beveled top inside the body *A*, Fig. 21, and their bodies fit freely in the aperture, thus giving the float. The driving pads *B* fit loosely for the same purpose, and the curve of their backs is not the same as that of the inside of the sleeve *C*. In the plan, the left-hand pad is shown engaged, while the right-hand one is free. What causes them both to hold or release simultaneously is the difference in the diameter inside the sleeve. In the upper part it is less than at the lower, so that when pulled down to the position shown in the elevation the pads are forced inward and bear on the flats on the shank or the collet. When the sleeve is raised (while the spindle is running), the chambered part of the sleeve comes opposite the pads, and they are thrown into it by centrifugal force, leaving the drill free to be caught by the hand.

Fig. 20 shows a pad type of chuck, made by Vickers, Ltd., of Broadway, London, S.W., England, in which release is also effected by raising the sleeve. This shows a collet in place, with a taper hole and slot at the top for the drill tang.

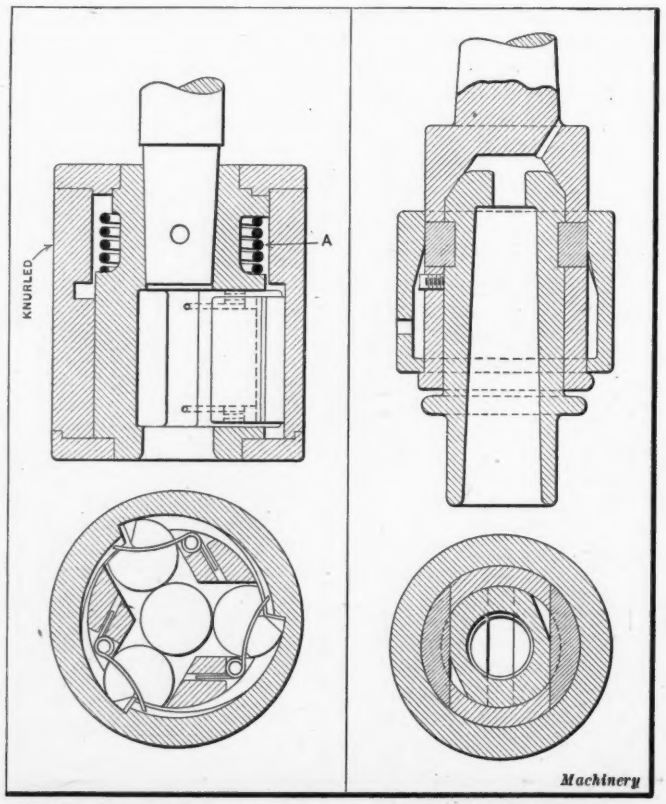


Fig. 19. Eccentric-jaw Automatic Chuck

Fig. 20. Pad Type of Quick-change Chuck

Examples of ball chucks are shown in Figs. 22 to 25, the first being that made by E. G. Wrigley & Co., Ltd., of Soho, Birmingham, England. In this, the balls abut against a collet having flats at 180 degrees, and transmit the drive through it. The sleeve is shown down in the driving position, keeping the balls pressed into action. When it is raised to a height limited by the set-screw in the groove, the weight of the collet and tool forces the balls outward into the pocket. On the reverse action, the balls are pressed inward and engage and drive the collet.

The chuck shown in Fig. 24, manufactured by Morton & Weaver, Coventry, England, also uses two balls. In this case a coiled spring presses the sleeve down and maintains the balls in the driving position, so that the chuck can be used horizontally or upside down.

The Modern Tool Co. of Erie, Pa., manufactures the ball chuck shown in Fig. 23, in which springs are omitted. The force of gravity draws the locking sleeve down and thus pushes the balls against the grooves in the collet. The positive drive in these chucks is disadvantageous for the operations of tapping and studding, and the firm supplies a special friction drive for use in such cases. Two fiber disks transmit the drive, and the pressure between their faces may be regulated by a nut. A stud-holder is also furnished to use in conjunction with the friction drive.

The addition of a ball race to take the running wear and to render the sliding of the sleeve easier is illustrated in Fig. 25. This chuck is manufactured by Alfred Herbert, Ltd., of Coventry, England. The balls *A* bear upon the grooved body. The ball and spring *B* lock the sleeve as shown, so that the chuck can be used in a horizontal or an inclined position, as well as in the usual manner. The collets are slotted through at the top, so that they will drive a tang, and access can be had to the end of the latter for the purpose of driving it out.

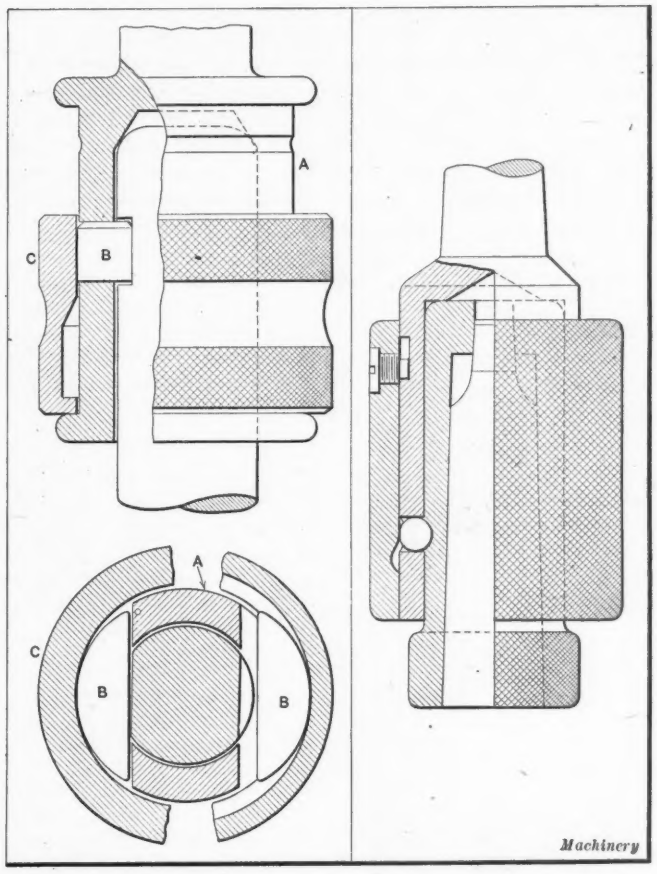


Fig. 21. Automatic Chuck with Floating Drive

Fig. 22. Wrigley Ball Type of Chuck

An example of a disk used for driving is shown in Fig. 26 (made by the Wiard Mfg. Co., Detroit, Mich.). These disks act in a similar manner to the balls in the preceding example, and fall into pockets in the sleeve.

* * *

## GERMANY'S MOTOR MIXTURES

Owing to the shortage of gasoline in Germany, experiments have been made with mixtures of alcohol and benzol. The results of these, as given by the American consul at Lyons, are of especial interest in view of the increased cost of gasoline in the United States and the need of finding additional uses for benzol at the close of the war. In these experiments, a 1914 Mercedes touring car, with the ordinary carbureter, was run 4.66 miles at a speed of forty-two miles an hour with one pint of a mixture of equal parts of alcohol and benzol. When the mixture contained three parts of alcohol and one of benzol, a distance of 4.34 miles was covered at thirty-nine miles an hour. In the proportion of one part of benzol and five parts of alcohol, the mixture ran the car 3.72 miles at thirty-six miles an hour. With pure gasoline, the car was run 3.60 miles at forty-four miles an hour, and with pure benzol, the car was run 3.79 miles at forty-two miles an hour.

* * *

## ACCIDENTS COST MONEY

Three kinds of accidents alone in Wisconsin last year cost workmen in that state over $800,000 in lost wages. Flying particles, resulting in eye injuries chiefly, caused a loss in wages of $323,000. Wearing goggles would have prevented much of this. Falls from stairs, ladders, scaffolds, etc., cost $300,000 more. Objects falling from cranes, trucks, etc., cost the injured men $195,000 in wages lost. An ounce of prevention is worth a pound of regret.

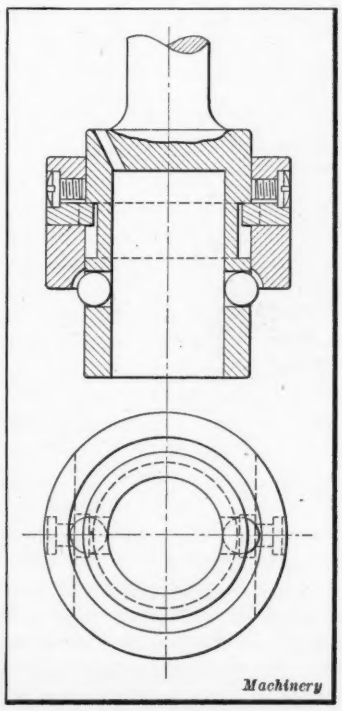


Fig. 23. Modern Tool Co.'s Quick-change Ball Chuck

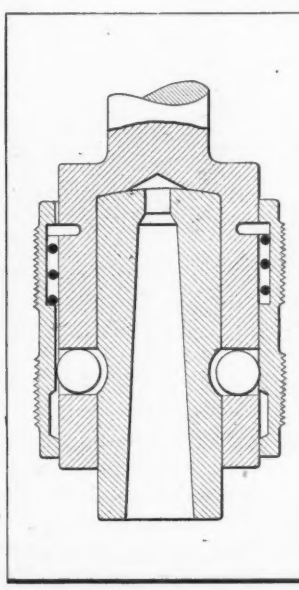

Fig. 24. Morton & Weaver Ball Type of Chuck

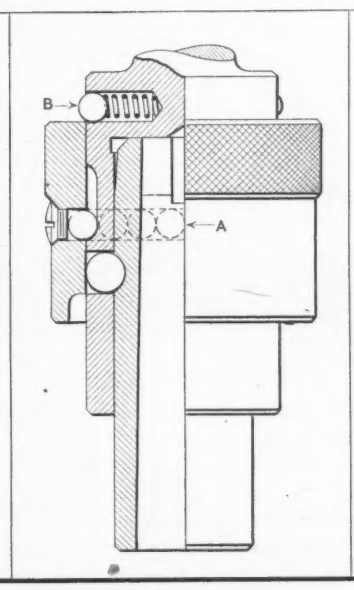


Fig. 25. Quick-change Chuck with Ball Race

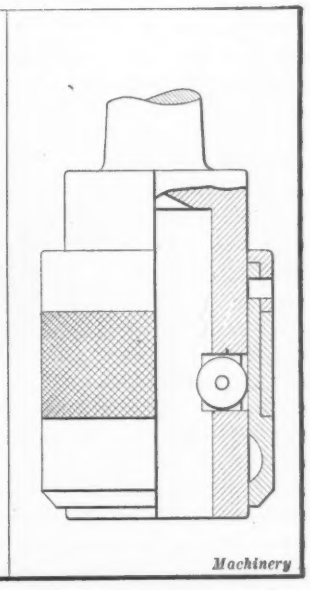


Fig. 26. Quick-change Chuck with Roller Drive

# GAGE GRINDING

BY CHARLES F. SCHLEGEL [1]

While the maximum space between the surface of the magnetic chuck of the No. 2 surface grinder shown in Figs. 1 to 4 inclusive, and the smallest wheel that efficient grinding will allow is approximately eight inches, much longer rod gages may be ground on this machine with a high degree of accuracy. The writer has ground on such a grinder rod gages 42 inches long. The operator should have a good set of size blocks for this work. A good set for the average machine shop consists of blocks ranging, by 0.001 inch, from 0.031 to 0.063 inch long, three blocks 0.03125, 0.0468, and 0.0625 inch long, respectively, to represent the fractions 1/32, 3/64, and 1/16, blocks ranging, by sixteenths, from 1/16 to 1 inch long, and blocks ranging from 1 to 10 inches in length. This set is not as expensive to make as first impressions may suggest, and it gives every measurement, by 0.001 inch, from 1/32 inch up to 11 inches by using a combination of not more than three of the size-blocks.

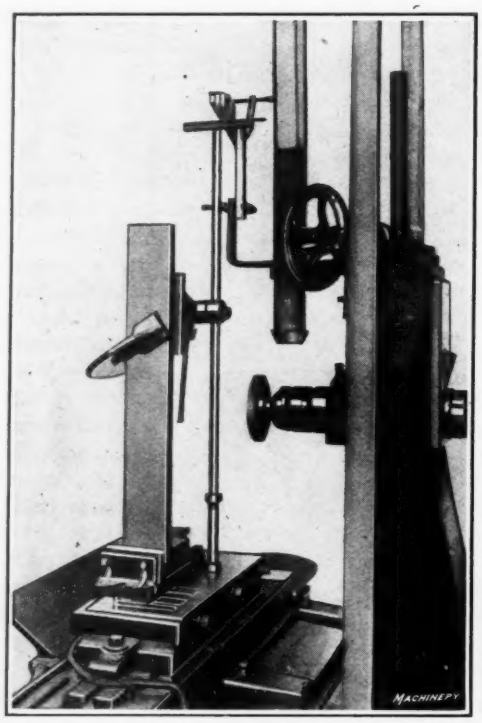

Fig. 1. Method of holding Work on Grinder

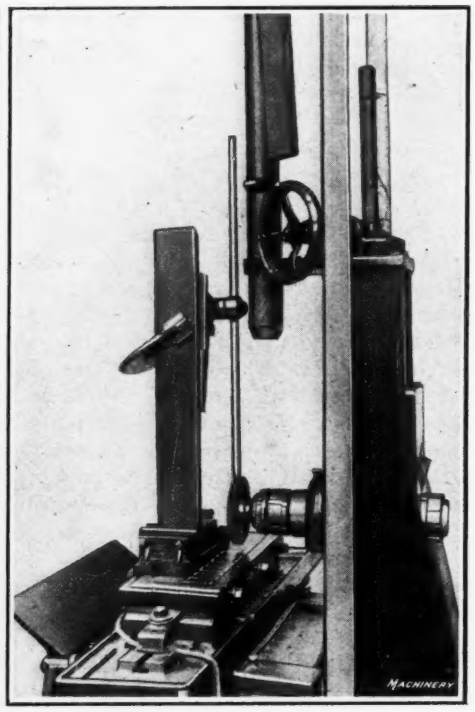

Fig. 2. Grinding Rod Gage

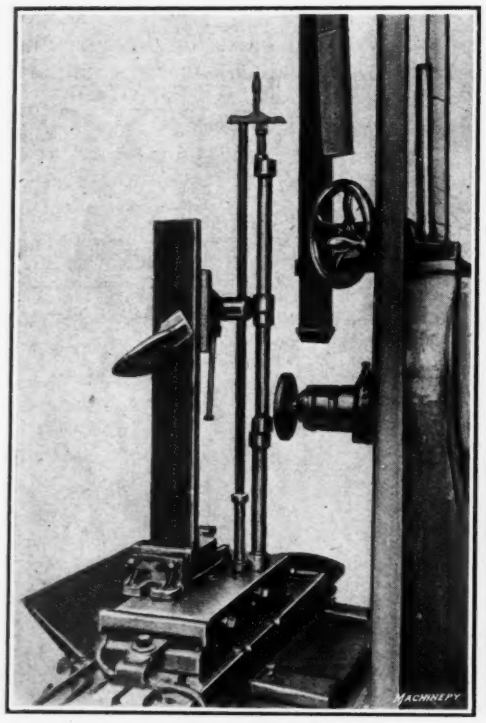

Fig. 3. Measuring Rod Gage

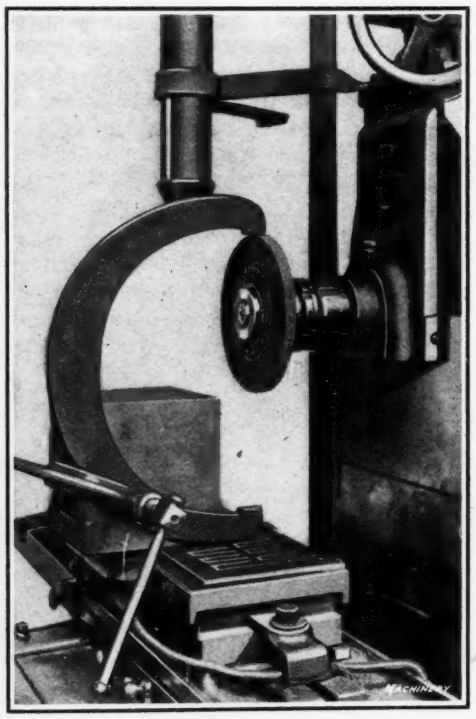

Fig. 4. Grinding Snap Gage at One Setting

There is no necessity of making any elaborate fixture for holding the rod gage in the machine. The articles shown in the illustrations are in common use in practically every shop and answer just as well. The rod holder is supported, as shown in Fig. 1, by a piece of 1- by 3-inch cold-rolled steel, of suitable length, held upright in the machine vise. The rod is held by a swivel holder, such as is used for holding a diamond while dressing off the emery wheel. This is clamped to the upright by a C-clamp of suitable size and is placed at such a height that when it grips the rod gage approximately in the center, the lower end of the gage, when vertical, will be about 5.035 inches from the surface of the magnetic chuck. This will leave sufficient space for a four-inch wheel and plenty of clearance to work in.

Having set this end in position so that it can be easily measured it is obvious that it should be ground last. So after loosening the binding nut of the swivel, the rod gage is turned end for end and, after squaring its sides with the surface of the magnetic chuck, approximately one-half of the stock left to be ground is removed. This is done by using the top of the emery wheel, the hood being removed as shown in Fig. 2. During grinding, the table should be moved back and forth and across by hand to avoid the jar caused by power feed. The rod is then turned back to its first position (it must not be loosened in the swivel) then accurately leveled and measured. This leveling is done by placing a parallel on top of the rod and leveling with an indicator (see Fig. 1), then turning the parallel horizontally through 90 degrees, and indicating again. This should be done two or three times, as leveling one way may throw it out another. Suppose the rod is 24.250 inches long, and that the mechanic is equipped with the size-blocks mentioned. Suppose also that 0.02 inch had been left for grinding and that 0.01 inch has been ground off one end; that the rod has been reversed so that the finished end is uppermost and leveled as just described. As the lower end is 5.034 inches from the magnetic chuck with 0.01 inch to be removed, the top of the rod is about 29 or 30 inches above the surface of the magnetic chuck. To measure this rod place the 10-, 9-, 8-, and 2-inch size-blocks one upon the other, as close to the rod gage as possible. This gives a height of 29 inches. The remaining fraction is then measured by the micrometer depth gage by placing the beam of the depth gage on top of the rod gage and running the spindle down on top of the size-blocks, as shown in Fig. 3. In this case, it should measure 29.294 inches, which equals the

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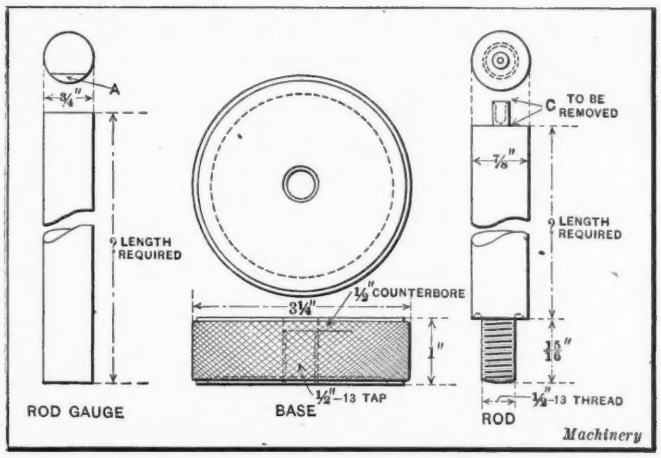



Fig. 5. Height Gage or Set Block for Planer

length of the rod, 24.250 inches, plus the space under the rod, 5.034 inches, plus the amount to be ground off, 0.01 inch. Then the bottom end of the rod may be ground, taking off a few thousandths of an inch at a time, but care must be taken to keep inside the 0.01 inch limit. After this is done, the 5-inch size-block should be placed on the magnetic chuck, directly under the rod gage, and the small size blocks from 0.034 inch to 0.044 inch used as feeler gages until one fits snugly between the bottom of the rod gage and the top of the 5-inch size-block. The difference between this block and 0.044 inch, in this instance, is the amount to be removed. This grinding should be done cautiously when nearing the 0.044-inch block so as not to go by but have a good snug sliding fit without having to use force to insert this block. Also care should be taken to see that there is no dirt or dust between any of the surfaces while measuring.

By this method of grinding, the gage is free to be measured, while working upon it, so the mechanic always knows just how he stands without having to resort to guesswork. Besides, a measurement of within 0.00025 inch can be maintained, which is close enough for all practical purposes where a long rod gage is likely to be used. It might be mentioned that it is a good plan to grind 0.002 inch off one end (before removing it from the grinder) about ⅛ inch from the edge, as shown at *A*, Fig. 5, to use as a lead and an approach to proper measurement. Where the rod gage is long, it should be fastened by a strap passed a little above its lower end to the upright standard in the vise, so as to avoid chattering.

### Height Gages and Snap Gages

A very convenient height gage or set block for planer work is shown in Fig. 5. This gage differs from the rod gage by being made up of two parts, a base and spindle or rod. The base is 3¼ inches in diameter and 1 inch in thickness; therefore the rods should be 1 inch less in length than what is actually wanted. Any number of rods can be used with the same base, thus forming a variety as large as shop production requires. The base should be pack-hardened and ground; also both ends of the rod should be hardened. One end of the rod should be ground on centers in a universal grinder; however, care should be taken to have the threads fit loosely enough to allow the rod to stand true on the base. After the rod is firmly attached to the base and the center *C*, Fig. 5, removed, the remaining end may be ground in the same manner as the rod gage. However, as only one end is to be ground, the gage may be held by the swivel holder near the bottom end so as to eliminate chattering without using the extra brace.

Another place where the top of the wheel can be used to good advantage is in grinding snap gages, as shown in Fig. 4. When set as shown, the gage may be ground in one setting thus insuring the two surfaces being perfectly parallel. The space may be measured by the size-block system or by inside micrometers. After the correct size is obtained, a lead of 0.002 inch may be ground on one jaw, as described for the rod gage. Then the two front edges may be ground with a cup-wheel, which is done by raising and lowering the wheel and grinding both jaws until both can be touched lightly by the wheel without moving the cross-feed of the table; this will insure an even start for both jaws when used for measuring.

* * *

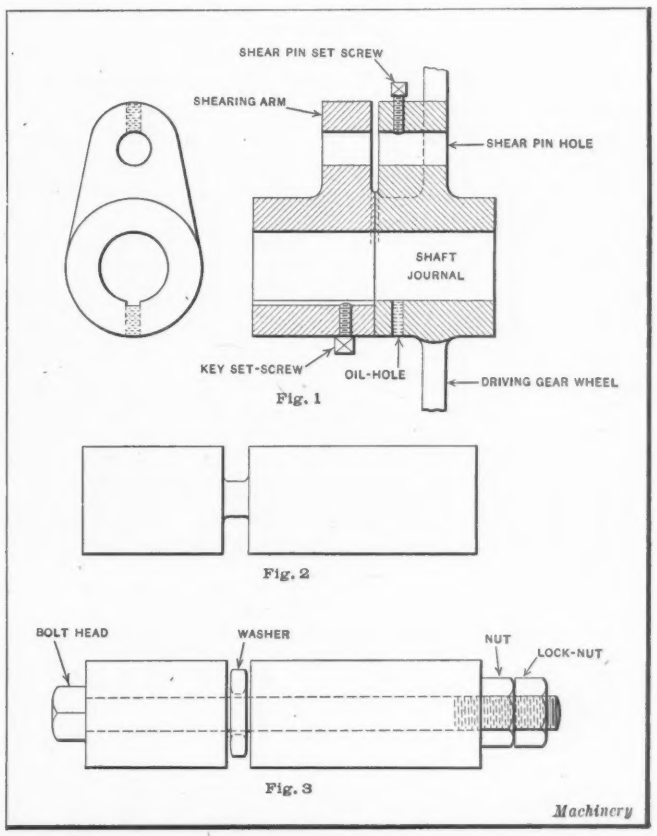
## IMPROVED SHEAR-PIN DESIGN

BY C. L. LOTHROP, Jr.[1]

To prevent damage to operating machinery, the flight and bucket coal conveyors built by a well-known contracting company are fitted with shear-pins or break-pins. This shear-pin is installed between a large gear-wheel and the shaft which it turns, as shown in Fig. 1. In the event of a heavy stress coming upon the conveyor itself, such as the jamming of a link due to a bearing getting out of alignment, the driving shaft will stop; and with it the shearing arm. The gear-wheel will continue to revolve, being driven by the motor; and the shear-pin, shaped as shown in Fig. 2, will break at the point where the diameter is reduced.

While the device is intended to operate only on rare occasions, conditions sometimes occur which cause the shear-pin to break several times a day. When this happens, an additional burden of machining new pins is thrown upon the already overworked machinists, and the conveying machinery may be broken down a considerable length of time while waiting for the pins. An improved design, shown in Fig. 3, has been tested and found to function in a satisfactory manner. A hole was drilled through the two larger parts of the pin to receive a ¾-inch bolt having a head on one end. On the other end, a nut was screwed, with a lock-nut holding it. The two hollow cylindrical parts were kept at the proper distance by a loose-fitting 3/16-inch washer, 1 inch in diameter. To prevent the hole from wearing to an elliptic shape, it was found necessary to make the 1 7/16-inch pins of mild forged steel, with the ends and hole casehardened, although tool steel might have done as well if the temper had been drawn before drilling and the pins had then been retempered. A fireman with a monkey wrench can put the conveyor in operation after a bolt is sheared, whereas when the solid pin was used, the services of a machinist were essential. The same result could have been obtained had the shear-pin holes in the gear-wheel and the shearing arm been bushed with hardened steel.

[1] Address: Naval Proving Ground, Indian Head, Md.




Figs. 1 to 3. Original and Improved Designs of Shear-pins

# MACHINERY

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We solicit contributions from practical men on subjects pertaining to machine shop practice and machine design. All contributed matter published exclusively in MACHINERY is paid for at our regular space rates unless other terms are agreed on.

## REPAIR PARTS FOR MACHINE TOOLS SOLD ABROAD

One of the troubles likely to develop in some American shops as the result of the abnormal European demand for machine tools will be difficulty in supplying repair parts. The demand for machine tools was so abnormal and methods of distribution so irregular, that in many cases no proper records have been kept of the ultimate destination of machines, and of the characteristics of the machines furnished. The result will be that concerns in Great Britain, France, Italy, Russia and other countries will communicate with the American builder of machines in their plants requiring new parts, and much cabling and correspondence will be necessary before the American builders will be able to identify positively the parts wanted. This means expense, annoyance and delay.

But if this is the only trouble experienced by machine tool builders who have worked their plants day and night to fill orders, we may well congratulate ourselves. The fear has been expressed that a considerable number of purchasers of American machine tools made in a hurry will have unsatisfactory experiences with them, and become prejudiced against American machine tools in general. It perhaps was inevitable that this abnormal demand should turn the heads of some of the manufacturers and cause them to rush out poorly finished work. The well established concerns whose products are known internationally as being well designed and well made have, in general, continued to turn out the same dependable product as before, and have kept careful records of foreign shipments. Concerns that have steadfastly maintained their excellence of product and dealt fairly with their foreign customers will stand as high with them after the war as before it.

* * *

## FIRE INSURANCE PREMIUMS

Every progressive manufacturer who contemplates the construction of a new factory or additions to an existing plant gives careful consideration to the provision of all the necessary facilities for securing high rates of production and enabling work to be done under conditions that will insure obtaining the required standard of quality. But in many cases it is apparent that the same care is not taken in investigating the requirements of fire insurance companies, so that advantage may be taken of the lowest premium rate that will afford adequate protection. Bureaus are maintained to which a manufacturer may make application for expert advice concerning safeguards that must be provided in a plant engaged in his line of work and other conditions that must be fulfilled in order to secure protection against fire loss; and by submitting plans to such a bureau it is frequently possible to obtain a heavy reduction in the premium without going to much extra expense.

A case in point is seen in the experience of a manufacturer who recently submitted plans of a new factory to the New York Fire Insurance Exchange. When experts in the employ of this bureau looked over these plans they found that the proper arrangement of fire doors had not been provided and that in one case a parapet extension of the fire wall had not been continued to the required height above the roof. These facts were reported to the manufacturer who immediately had his architect modify the plans in accordance with the bureau's finding. As a result, an additional investment of $350 saved $1000 in the insurance premium.

* * *

## BUILDING UP AN ORGANIZATION

The manufacturing concerns that have achieved a reputation for square dealing and general reliability are those which by years of effort and training have built up an organization of efficient and loyal employes. Concerns that make a practice of attracting men from other organizations by offers of high salaries are not organically sound, nor are they likely to become sound and efficient by pursuing this method of recruiting. Manufacturers that employ machinists have found that a dependable organization is that which has been built up by training young men, and making places for them when they become journeymen.

Every manufacturing establishment requiring mechanics and skilled workmen should, as a matter of justice, educate a certain percentage of its employes each year in the elements of its trades. The practice is necessary in order to provide the number of workmen required in the industry, and it is the best kind of insurance against strikes and labor troubles generally. The men in a built-up organization composed mainly of employes who have spent the best part of their lives with the company and know its history, aims and ideals, feel themselves to be a part of the business and not mere hired men; they are not, as a rule, looking elsewhere for any chance to obtain employment at higher wages. On the other hand, an organization composed of self-seekers is unstable, because the men are disloyal. Loyalty cannot be obtained by the payment of mere wages; it is obtained only by fair treatment and by making the employes feel that they all are a necessary part of the organization.

* * *

## MISUNDERSTANDINGS IN JOB WORK

A common cause of trouble between jobbing machine shops and their patrons is in the misunderstanding of what is wanted. Work is often sent in and a few verbal instructions are given, with the result that when the job is done it is not as desired, and one blames the other for the mistake. The owner of the parts thinks he knows exactly what he wants, and expects that the job shop proprietor or his men should be able to read his mind after a few words of explanation.

The job shop proprietor should generally insist on getting clear and definite instructions on the work wanted. If the customer will not or cannot furnish drawings, it would pay the proprietor to make sketches and get the customer's O.K. before starting work. Then there should be no "come-back" if it does not meet the customer's needs. He had the opportunity to correct his own mistakes and the misunderstandings of the shopmen when he examined the sketches.

All orders and agreements should be made in writing, and prices should be specified either as to hourly rate or total for the job. The job shop proprietor who consistently follows business methods in dealing with his customers will avoid many of the troubles common to job shop practice.

## INDUSTRIAL EFFICIENCY

BY FRANK METZLER [1]

If the time to prepare for war is when peace obtains, the time to prepare for the domestic competetive era that is to confront the manufacturer of tools and machinery at the close of the war is while we are experiencing the unusual pressure due to the production of war commodities. Industrial engineers are not alone in speculating on the aftermath of this feverish activity and, in many instances, heart-breaking suspense and the reaction to be experienced by both large and small manufacturers. Munitions have almost upset manufacturing reason. Many good, conservative men, whose word for results and deliveries was dependable, have lost quite materially in promising deliveries that were impossible. As time dragged on, the expense outran the profit and these men were replaced by others, and the successors, in turn, were followed by others, all with inflated ideas as to the possibilities of delivery; but each failed to profit by his predecessors' errors.

We are all familiar with the jaunty air of the manufacturer on receiving his first munition order. He is a man envied by his fellows. Later he has a more serious mien, then a worried expression, and, finally, we count the failures. In nearly every case the cause can be traced, not to an article impossible to manufacture, but to a management that failed to grasp the true situation concerning deliveries of tools and machinery, material, and a peculiar labor condition. Those issuing the contracts stipulated, in nearly every instance, delivery dates impossible to meet, and attached penalties for failure to meet them. The manufacturer was induced to believe in himself, his organization, and equipment, and agreeably signed. Then followed an investigation and analysis of his executive force and a decision to secure a more capable organization. Mechanical engineers and superintendents became mere passing acquaintances. Tools were designed on the run, so to speak, and scheduled against an equipment which, through continued failure of deliveries, was substituted by others. In the meantime, the hastily designed prospective tools were placed on an hourly basis in almost any shop with a semblance of equipment, only to be thrown into the scrap heap because they could not be used with the new equipment. Efforts were immediately begun to make up for the unlooked for delay, by high pressure and long hours. Engineers and superintendents alike failed to satisfy a management almost beside itself and haunted by the penalty in the contract. New men were secured. The previous tooling was criticised and new tools were designed, only to meet the same difficulties that attended the former. Some firms retooled their equipment four times before manufacturing proceeded. In addition, in no case (except those previously engaged in munition work) was the entire equipment charged in against the order which, through failure of deliveries, and the consequent penalty, became a constantly diminishing quantity. All the manufacturers figured that after the order was run off they would have an equipment for general jobbing purposes. In many instances, the cost of repeated tooling precluded any possible profit on the first order so the question resolved itself into the securing of a second order or failure. The small fortunes made by the small shop men, are sad reflections on otherwise capable managements. The prices paid for tools were outrageous, being as high as 200 per cent above normal, and all have repeatedly wondered at the cheerful endorsement of bills.

The fallacy of justifying an expenditure for equipment for general jobbing purposes might as well be recognized now as later. What sane manufacturer would deliberately buy the assorted equipment usually obtaining for munitions and instead of munitions do a general jobbing business, even in the abnormal present times? What then is to be said for those so equipped when times become normal? Without question the country will be confronted with an overproduction of certain classified machines, and the problem of keeping them employed is one to harass the most resourceful executive. When the full significance of this wild and extravagant buying of machinery and tools is appreciated, and manufacturers are sobered by the accumulating idle hours day after day, it is fair to assume that a wholesome regard for a more advanced knowledge of proper business methods must obtain. Such being the case, it follows that if, during normal business times, such as obtained before the war, it is found advantageous and profitable to employ a management embodying the most efficient means of conducting business, it would be doubly profitable now.

There is no question but that an orderly systematic flow of work is more conducive to profits and the meeting of due dates than the unorganized manner of approaching the problems of manufacturing. A trained corps of experts with the attending investigations and analysis will do far more than the average all-around good man who is generally relied upon to determine processes and proper methods. An apt illustration is to be found in the conditions surrounding the heat-treatment of steel; mills are experiencing trouble in supplying the market with the various brands of steels, and factories are experiencing trouble in heat-treating. This is not local; it is a general condition and the cause is self-evident. There was never more need of organized investigation and scientific application in this department than at present, when time is the greatest factor. Yet managers allow this department to continue as formerly, sustaining a loss in many cases not known to them, with the consequent delay on deliveries. Regardless whether the much heralded "war after the war" is to be realized or not, it behooves all manufacturers to investigate the more modern methods of conducting business.

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* * *

## HEAT DENSITY

BY GEORGE P. PEARCE [1]

We hear a great deal about the B. T. U. value of fuels, that is the B. T. U.'s of potential chemical energy contained in one pound of various substances, but how many have considered the number of B. T. U.'s of heat that are in a cubic foot of space under various conditions? Let us assume 0 degrees F. as a base and see approximately what the heat density is for various conditions and substances. On a hot summer day, with the thermometer registering 110 degrees, there seems to be plenty of heat everywhere, yet a simple calculation will show that there is only 1.8 B. T. U. to the cubic foot.

The gasoline blast torch is generally looked upon as a very hot flame, but in the hottest part of that flame the heat density is less than expected; it is 10 B. T. U. per cubic foot. Hydrogen gas, with its enormous heat value, might be expected to make a better record than that, yet in the hottest part of a hydrogen flame burned in air the B. T. U.'s per cubic foot are just about 10.1; it has a heat density 1 per cent better than the gasoline flame in air. Not much is expected of carbon burned in air with its much lower heat value, so we are surprised when it shows a density of 12.3 B. T. U. per cubic foot. This, of course, is due to the greater density of the products of combustion. Incidentally we note why coal is such a satisfactory source of heat for boilers; it develops a high heat density and thus rapidly heats the tubes; of course other things enter into consideration as well. A great deal is said about acetylene, and it deserves credit, for this gas burned in air produces a heat density of 13.1 B. T. U. per cubic foot. So far the heat produced has been diluted by the presence of the inert gas nitrogen in the air. Eliminate this and burn acetylene in oxygen and a great change takes place, for now there are 24 B. T. U. in every cubic foot of the intense flame. Burn hydrogen in oxygen and there are 20 B. T. U. to the cubic foot.

It might be supposed that the limits for heated gases and vapors are being rapidly reached. However, ordinary steam just as it boils off water into the atmosphere contains 44 B. T. U. to the cubic foot. The oxy-acetylene flame takes a poor second place when compared with steam under these conditions. Some experimental high-pressure, high-efficiency, steam engines use superheated steam at 240 pounds per square inch and 300 degrees of superheat, and every cubic foot of this steam contains over 500 B. T. U. Strange as it may seem, saturated high-pressure steam at 235 pounds per square inch contains over 650 B. T. U. per cubic foot, and for carrying heat is

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superior in this respect to superheated steam. More astounding still is the humble cake of ice which at 32 degrees is prepared to deliver 937 B. T. U. per cubic foot when cooled down to zero. Boiling water is common enough, and as a heat container it holds over 12,000 B. T. U. per cubic foot.

Melted sulphur, at 800 degrees F., has a heat density about twice that of boiling water, or over 22,000 B. T. U. to the cubic foot. Melted aluminum, at 1214 degrees F., almost doubles this with nearly 43,000 B. T. U. per cubic foot. Melted glass, at 2377 degrees F., has nearly 75,000 B. T. U. in every cubic foot. Platinum, at 3300 degrees F., makes a big jump with its 182,200 B. T. U. per cubic foot. But common melted iron, at 2700 degrees F., leaves platinum away behind with 207,000 B. T. U. per cubic foot. However, they are all surpassed if a cubic foot of carbon is heated almost to its vaporizing temperature, say to 7000 degrees F., as a heat density of 700,000 B. T. U. per cubic foot is then obtained. It is impossible for a person to look at this heated carbon or stand near it, and probably it represents the greatest heat density known. It is found in every arc lamp. Perhaps when we obtain more data on the remarkable metal tungsten, which takes 5432 degrees F. to melt it and an unknown temperature to vaporize it, a still greater heat density may be had in melted tungsten just before it commences vaporizing.

## PRESS-ROOM EFFICIENCY METHODS

BY G. R. SMITH [1]

While many times small things appear unimportant and the study of detail seems like a waste of time, this study is really a vital matter and one that must never be lost sight of in an endeavor to reduce cost and increase production. A lubricant on all drawn metal work makes the process easier on the tools, machines and work to be done. Usually, this lubricant is placed on the blanks by brushing them or by dipping them in the solution before placing them in the dies. In either case, this must be done by the operator or a laborer employed for the purpose; if it is done by the operator, the piecework price is made to cover this operation. A better plan is to use the drawing solution in the cutting of the blanks, instead of the lard oil generally used for that purpose.

In blanking operations on straight press work, the writer has used, to advantage, a soap, water and oil emulsion on brass and copper blanking, and a lard oil and chalk solution on steel blanking. They give the same results as pure lard oil in keeping the tools from heating and the metal from flaking off, scratching and sticking to the dies. By this plan, the blanks come to the drawing operation lubricated and ready to be fed at once into the dies, increasing the production and lowering the cost. On all work that is cut from the strip, this plan may be easily followed, as the strips can be oiled with this solution in place of the usual oil. While large blanks that are cut on the shear cannot be handled in this way, the saving on the small blanks more than pays for an oiling operation on the larger ones.

### Use of Compressed Air

Many up-to-date shops use compressed air in the press rooms. It may be supplied by piping that connects the compressor tanks with each machine, or by a small pumping attachment bolted to the main casting of the machine. While compressed air is rather expensive, its great cost-reducing powers and economic value in shop manufacturing operations, especially press work, more than offset the first cost. It may be used for removing work from dies, blowing work through open-back presses into work boxes, removing work from certain style jigs in the drill press, keeping dies free from scale, chips, and dirt, removing punchings from tapped holes, furnishing power for automatic feed devices and for the side stroke in double-action dies; it has also been used as a bumper pad for the pressure ring in shell-drawing dies.

### Positive Knock-out

The use of the top, or positive, knock-out is well known, but a word may save someone a lot of trouble and experimenting. An operator should not be permitted to remove work with a pair of pliers, old file, or the like if there is any chance whatever of having the work pull up on the punch and knock off at the top of the stroke with the positive knock-out. This plan lessens the cost of the operation, the danger to the operator's fingers, and the possibility of damage to the dies by the ram of the press descending with the file or other probe in them. The writer has drilled a hole from the top of the punch shank to carry a knock-out pin, with an inch or so of spiral spring in the center, when the stroke was too long to work with a solid pin. All springs should be removed from the stripper plates on the punch and the top knock-out used if there is any chance whatever of doing so, as the cost of operation will be reduced and the result will be more satisfactory. Sometimes it is necessary to place a piece of cushion rubber on top of the pin, that is, between the pin and the knock-out, when the stroke of the press and construction of the tools will not allow of any other method. The side attachment knock-out can be used when it is impossible to use the top, back, or positive knock-out.

In blanking washers, a knock-out with a tapped hole in the end may be used. A pin screwed into this hole will run down the center of the punch and push out the punchings in compound blanking and piercing dies, when the construction of the tools will not allow a stripper pad in the center for the knock-out pin to rest on.

### Magnetized Punch

A magnetized punch is a practical and efficient tool; it has an electromagnet in the center and is arranged so that the current is switched off with the full rise of the press ram. It works well on steel parts, either in forming operations or blanking. The fault with the average sub-press and precision die is that it leaves the blank in the strip of stock from which the operator has to either pick or shake it out.

### Spring Attachment for Straight Cut-off Work

In Fig. 1 is shown a small spring attachment that has been successfully used on straight cut-off work. This is simply a strip of flat spring steel, bent to the desired shape, passed through the bolt hole in the side arm of the press ram, and held in position by a wooden plug driven in the hole with it. This strip is bent so as to press on the end of the work when the latter is cut off by the punch as the ram of the press descends. Then, as the operator feeds the stock through the die he forces each piece out as it is cut, the spring holding it down so that it slides out easily. With this arrangement, work may be run on "continuous trip," which could not be run on trip in any other way. The cost of production can often be lowered 75 per cent by the use of this spring.

### Stripping Work from Single Piercing Punches

In piercing small work, such as washer blanks, where a single punch is used, a piece of cushion rubber placed on the punch after it is set up will force the blank off the punch as it rises out of the die. This is an old device, but nevertheless is unknown to many. When rubber is not available corks will give the same result when the piercing punches are ¼ inch or less in diameter and the stock is not over 0.030 inch thick. Placing a spiral spring around the punch, holding it in position by wire, will accomplish the same result. If a washer is clamped in such a position that the punch travels through its center, the work will be stripped as the punch travels back through the washer. A piece of flat stock with a hole drilled in it can be used for the same purpose, and is often much easier to arrange than a washer. These methods will be found of value in shops where a great deal of special work and jobbing is done and the tools cannot be made and kept on hand for each piece of work that comes along.

### Cooperation of Two or More Operators on One Press

Recently, several operators were tried on an assembling job on a punch press, but none of them could finish more than one hundred pieces an hour. They could assemble one hundred pieces in fifty minutes and press them in ten. When two operators were put on the job, each assembled one hun-

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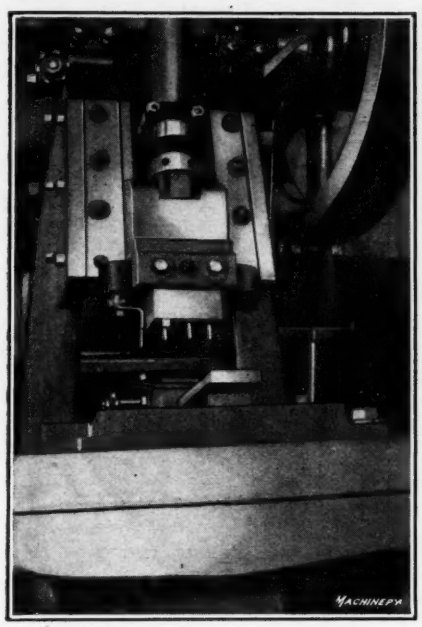

Fig. 1. Spring Attachment used on Straight Cut-off Work

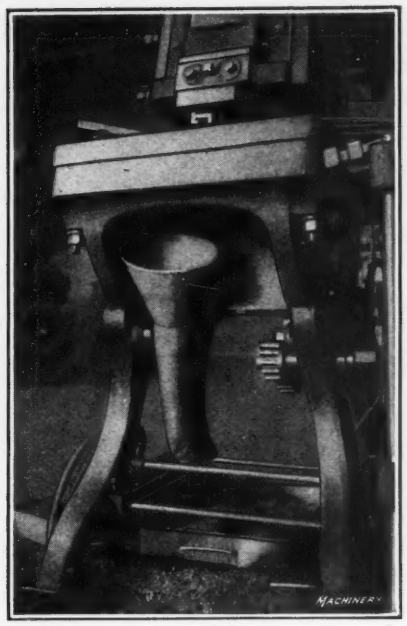

Fig. 2. Arrangement of Conveyor for separating Work from Scrap

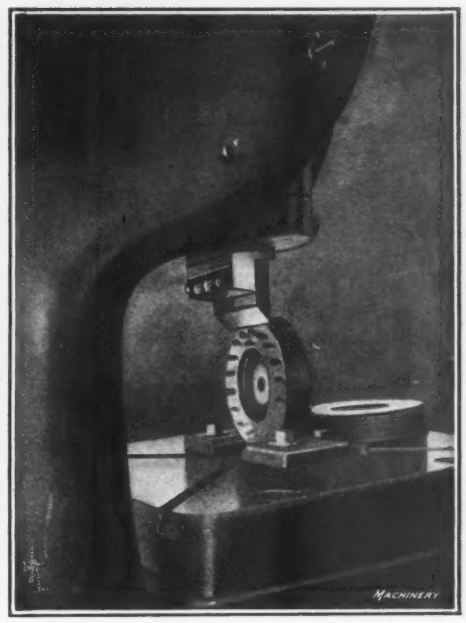

Fig. 3. Shear Punch for removing Bolt Ends from Gear Blank

dred pieces an hour, thus earning his piecework allowance. A third operator was put with them and two could assemble enough to keep the third pressing all the time, with the result that three hundred pieces per hour were made and each operator made his piecework allowance. The production of this work was thus raised from one hundred to three hundred pieces an hour; the cost of producing was practically the same, but deliveries were made that before had been thought impossible. There was a slight saving in factory expenses, as three operators were working on one press, thus saving the cost of power for two machines that the other two operators would be running under normal conditions. In shops where conditions would allow, the assembling could have been done by much cheaper help, thus effecting a greater saving.

### Use of Feeding Pliers

The use of pliers for feeding press work is a good safety measure. They will be found, in some cases, to be more efficient in handling small work than the operator's fingers, much safer, and, in case of accident, will cost less to the manufacturer. While the market is flooded with safety appliances for the punch press—many of them very good in their way—the one great factor, and the only absolutely sure precaution, is not to have the fingers between the dies when the ram descends.

### Increasing Speed of Press

While the makers of power presses give certain speeds that should not be exceeded, and the executive who has charge of the machines should know what those speeds are, some machines can be safely speeded up on certain classes of work. While the writer would not advise the novice to tamper with the speed of a press, an increase of, say, ten to fifteen strokes per minute on certain classes of work that can be run on continuous stroke, or trip, involves no danger whatever to the machine, but does mean dollars saved to the manufacturer. The changing of driving pinions means time and an extra pinion, as well as the services of a millwright. But the speed of a press may be increased by winding an eighth or quarter inch of gummed tape on the pinion of a belt-driven press; this can be easily removed when it is desired to run the press on other work.

### Sifting Washers from Scrap

In all shops where washers are extensively made, they must be separated from the scrap that comes from piercing the center hole. This is done in a number of ways, sifting being the most common. A sieve is used that will hold the washers but will allow the scrap to drop through. The writer has avoided this sifting operation in many cases by driving one end of a piece of steel wire into a block of wood and then placing it under the press in such a position that the washers will drop or string themselves on this wire, while the scrap falls in pans placed to receive it; the top end of the wire is turned down as a pilot. It is possible to stack a great deal of press work as it drops from the dies, thus saving time and expense that would be used in sorting and sifting operations. Small tin conveyors, such as shown in Fig. 2, may be used to divide the work from the scrap as it drops from the press.

### Prevention of Scaling and Use of Shear Punch

Large blanks should be tumbled before drawing, to remove scale and give a smooth polished surface, equal parts of sea sand and granulated cork being placed in the tumbling barrel with the blanks. They come out as smooth and polished as when buffed. The cost of tumbling is slight, but the process will effect a large saving on the dies and give a much better shell. The scaling of small steel pieces, such as eyelets, small shells, ferrules, etc., in the annealing can be easily prevented by nickel or brass plating or dip before annealing. Brass does not scale and the plate thus protects the steel from scaling.

In Fig. 3 is shown a set of press tools that comprises a steel shearing punch and two clamps. Their use lowered the cost from fifty cents a piece to fifteen cents per hundred pieces. The work is a gear blank built up of laminations held in place by eighteen ¼-inch steel studs protruding about ½ inch through a side piece of ¼-inch boiler plate. These protruding ends were formerly cut off with a pneumatic chisel, one at a time, the operation paying fifty cents per finished blank. The studs on one side are now cut off with three strokes of the press, paying fifteen cents per hundred blanks. The only tool is the shearing punch which cost $3. The holding nest is two clamps bolted to the bedplate of the press, thus holding the blank in position, and allowing it to be turned as required by the operator.

* * *

A device for testing the safety and carrying strength of floors, walls and columns has been invented by a building inspector of Seattle, Wash. This device, which he calls the "extensometer," is said to be so sensitive that it will measure 0.0001 inch. The device is used to measure the amount of change produced by a load, for when a floor slab is loaded, the under surface stretches and the upper surface is compressed. By measuring the amount of the change thus produced and taking into consideration the kind and quality of the material and the load, it is possible to figure the safe carrying capacity of the building. This device is particularly adapted for concrete structures, because the weak places of these are not otherwise easily discerned.

# SNAPSHOTS ON THE ROAD

A HIGH WAGES ASPIRANT—FITTING ROUND PEGS INTO ROUND HOLES—FIRE PREVENTION HINT—THE EFFICIENCY EXPERT

DOWN in New England there is an old machine tool builder who has a reputation for making good, serviceable machines. Incidentally, he isn't strong on technical education, and sometimes the younger men in his organization are inclined to set him down as a back number. However, his "horse sense" often saves the day for them, as the following incident will show.

"—he's going to stand on that shaft to oil those top bearings"

One day he gave one of his machine designers a feed-control shaft to lay out. It was a long, horizontal shaft, located at the front of the machine about a foot from the floor. As the shaft had very little load to carry, the designer estimated that ⅞ inch diameter would be ample to give the necessary strength, and so informed his superior. But the old machine builder chuckled when the designer told him of his figure, shook his head, and said:

"Say, young fellow, you forget that when the machinist who runs this machine starts it up on Monday morning, he's going to stand on that shaft to oil those top bearings. Maybe he'll be a 200-pounder—better make that shaft 2 inches diameter and you'll be on the safe side for everything."

Which goes to show that the factor of safety must include the human element.

### A High Wages Aspirant

We hear a great deal nowadays of the mushroom growth of certain lines of business, and the spirit of the times must have permeated the minds of a great many untrained fellows who are anxious to enter the high-wage class of munition plant employes. At least the following episode would lead one to think so. A chinless individual recently inquired at a prominent New England manufacturing establishment to see the superintendent. After having gained the audience of that busy man, he asked in a confidential manner, "How much would you charge to teach me to run a universal milling machine?" The superintendent, quite taken aback, replied in astonishment, "Why do you want to do that?" To which the hopeful aspirant replied, "I have a job offered me for tomorrow to run one, and I want to learn all about it before I start."

### Fitting Round Pegs into Round Holes

In a large New England manufacturing establishment that conducts an extensive apprenticeship system, the boys are taken in on a two months' trial. If they prove to be adapted for a mechanical career, they then go on and complete the four-year course. The following incident will illustrate one of the ways in which the unfit are eliminated. In the early part of the course, all the boys work in one training room, from which they are later transferred to the various departments in which they are to work. At about eleven o'clock on Saturday morning it is customary to stop all the machines, divide the boys into squads, and commission each squad to wield a broom, brush, waste, or some other cleaning implement. Some of the older apprentices act as gang bosses, and one day an unsophisticated country youth, having completed his allotted portion of work at a quarter of twelve, asked his apprentice boss what else he could do. The apprentice boss, having a perverted sense of humor, suggested that he take his oil-can and thoroughly oil the heads of the nails that protruded from the wooden floor, starting over near the foreman's desk. This being the first Saturday the boy was there, and supposing this to be part of the general Saturday clean-up, he seized an oil-can and, starting by the foreman's desk, proceeded to oil each and every nail head, made shiny and smooth by constant wear. The process of elimination was greatly accelerated in the case of this youth, for he had not oiled many nails when the foreman turned and saw him.

"—he had not oiled many nails when the foreman turned around and saw him"

### Fire Prevention Hint

In roaming through the shops many things are seen which, though not mechanical, are interesting from the standpoint of general welfare, efficiency, safety, etc. There may be a variation of opinion as to the class in which the article to be described belongs. That point may be left to the judgment of the reader.

This cigar holder, for that is what it is, is placed in a conspicuous position in the office near the door which leads into the factory of a large Central New York agricultural implement manufacturer. Its use may be inferred by one who is familiar with the propensity of traveling men to smoke wherever they go. When a salesman calls at the factory and is ushered into the office holding in his fingers a lighted cigar, no remark is made. But as soon as he rises with the purchasing agent to go into the factory and endeavor to explain why his particular steel or machine did not make good, he is confronted with the sign which reads "Smoking not allowed in shop. Place your cigars here." He needs no further hint, but drops his cigar into one of the grooves, noting the number, and proceeds glumly into the shop with his guide. But when he returns, he finds his cigar safe and well preserved—from a sanitary standpoint. It is interesting to note that there is no provision made for the man who smokes a pipe; but, then, what excuse has a salesman for smoking a pipe when he's on the road?

"—drops his cigar into one of the grooves"

### The Efficiency Expert

The efficiency expert, having been sent from the home office to infuse efficiency into a smoothly running and

highly productive shop organization, in which the superintendent takes considerable pride, entered light-heartedly upon his duties. He found the superintendent at his desk, planted himself in a chair beside him, and told him that he had been authorized to install certain systems in the plant. He hoped that they would be able to work harmoniously together, and that there would be no difficulty due to divided authority.

The superintendent, who had had some experience in the past with efficiency experts, replied: "I have no objection whatever to your installing any systems in this shop that you deem advisable as long as you do not interfere with the present efficiency of the plant or its output. But in case I find we are running to system instead of to output, you will agree that it will then be time to interfere."

So the efficiency expert will play around, spending some of the company's money, without interference so long as the present efficiency is not lowered and the output is not cut down.

* * *

## LANTERN PINIONS IN CLOCKS

BY GUY H. GARDNER[1]

Every machinist who has investigated the interior anatomy of the family clock, as probably most of us have, must have been struck by the peculiarity of the pinions. These, instead of being cut as in machinery with which we are more familiar, are the so-called "lantern pinions," made of two disks between which are "rounds" of steel rod to serve as teeth or leaves. In earlier days, this form of pinion was sometimes employed in other than horological machinery because of the ease of its construction with limited tool equipment. For instance, a photograph of a windmill in New England, built before the Revolutionary War, shows wooden gears meshing with lantern pinions which were also made of wood. In some of these early examples of primitive millwright work, the rounds were made to turn in the shrouds, doubtless for the purpose of diminishing friction. Apparently, however, this construction was soon found to be erroneous, as the rounds were later made fixed.

Many machinists, wondering at the persistence of these lantern pinions in nine-tenths of American clocks, consider them "vestigial remnants" like the human appendix. Some seem to attribute their survival to ironclad conservatism, some to a supposedly greater cheapness of manufacture, while some deem the designers ignorant of more modern and more suitable modes of construction. The skill, knowledge, and progressive spirit of the makers of clocks need no vindication, for anyone who will spend a day in looking through one of their factories, observing tools, designs and methods, will be convinced that clockmakers are fully up to date.

Why, then, do they continue to use what a reader of MACHINERY, in a recent letter, calls "an outworn, unmechanical monstrosity"? Because it is neither outworn, unmechanical, nor a monstrosity. For the conditions under which the ordinary low-priced clock has to operate, it is far superior to the best cut pinion. When a pinion is to drive its gear, the lantern is out of the question, being entirely unsuited to this service; but in every part of a clock train, save one, the pinion is the driven member.

As we all know, the average cheap clock must be planned to run as long as possible without skilled attention. Most owners of watches have them cleaned occasionally, but how many ever take a clock to the repairer for cleaning until it utterly refuses to tick? Thousands and tens of thousands, moreover, are exported to countries that we consider uncivilized, where they are never cleaned or oiled, but must run until entirely worn out, and we may be sure that those purchased to replace them will not be of the same make, unless the "uncivilized" owner has found them longer lived than their numerous competitors.

Two qualities render the lantern pinion especially suitable for use in a movement that must operate under such conditions. An accumulation of dirt that would stop the action of any other form of tooth is simply pushed through between the rounds, and the pinion continues to perform its function. The second point of superiority is less obvious. Anyone who will draw, to scale, an epicycloidal-tooth gear, driving a lantern pinion, and study their action will find that a lantern pinion of seven or eight rounds will work as smoothly as a cut pinion of ten or twelve leaves. As the possibility of using coarser pitch makes the mating gear both cheaper and stronger, the claim of superiority of the lantern will be seen to rest on a solid foundation. Another point of some importance is that slight variations of center distance have a less detrimental effect than with other forms of pinions, so that a clock will continue running after its pivot holes are considerably worn and the accuracy of the original "depthing" sufficiently impaired to put a cut pinion out of commission. For clocks which, by reason of their greater cost, will presumably receive adequate care, the lantern pinion presents no advantages, and in them the cut pinion is commonly used.

The accuracy attained in the manufacture of the lantern pinions will surprise anyone who has regarded them as crude. A person may examine thousands without finding one that exceeds the limit of 0.0005 inch variation in pitch diameter, and the excellence of the fit of the rounds in the holes drilled for their reception is equally admirable. The one place where the pinion is the driving member is in the "motion work," which we might call the "back-gear," the train of two pinions and two wheels that causes the hour hand to make one revolution to twelve of the minute hand. Here, as far as the writer is aware, cut pinions are always used.

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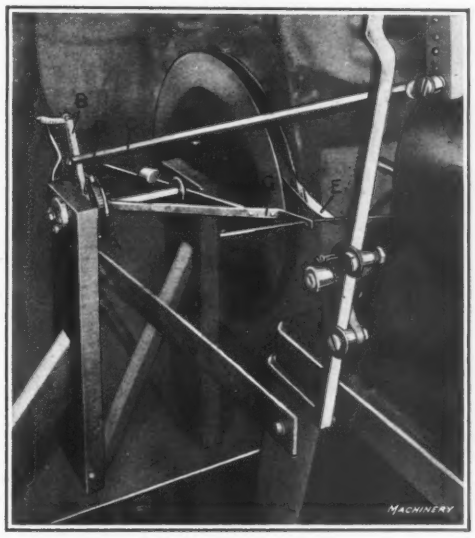
* * *

## AUTOMATICALLY OPERATED STOCK REEL

An automatically operated stock reel belongs logically with an automatically fed press, and unless automatically fed presses are equipped with a good fool-proof reel like the one described below, there is no end to the trouble and expense that may be incurred. At the factory of the Frank Mossberg Co., Attleboro, Mass., there are several press jobs which run continuously from one year's end to another. It is through the courtesy of this company that we are enabled to present the accompanying illustration and information. The apparatus is constructed so that the reel proper can be easily removed to give free access for replenishing the stock. The reel is fixed to the main shaft, as is also the fine-pitch ratchet wheel *A*. The lever *B* swings freely on the main shaft and constantly oscillates while the press is running, power being transmitted to it from the press by the connecting-rod *C*. Lever *B* is oscillated once for every stroke of the press. Attached to lever *B* is the ratchet dog *D*, which is prevented from engaging with the teeth of ratchet *A* so long as the strip of stock *E* is hanging slack from the reel. As soon as the stock feeds far enough into the dies to take up the slack in the strip, the trip arm *G* is raised to the position shown, at which point the dog cam *H*, which is integral with it, has rotated far enough to allow the pin protruding from dog *D* to drop into a hollow on its periphery. This, of course, brings dog *D* into contact with ratchet wheel *A*, and at the next reciprocation of the lever *B*, the reel is rotated a full turn or some fraction according to the momentum given it. This runs out a considerable amount of stock, allowing the feed lever to drop down, which holds the dog out of engagement again until the stock becomes tight again.




Automatic Stock Reel attached to Rear of Press

V. B.

# OIL-GROOVING GEAR SHAPER SADDLES AND UPPER INDEX WHEELS

BY JOHN G. BRUEGGEMAN [1]

Proper distribution of the lubricant in bearings, especially vertical bearings, demands more or less elaborate oil-grooving, from the simple helical groove to the more complex irregular kind. Cutting such grooves by hand is a laborious, time-consuming, and generally unsatisfactory process; yet for machining these grooves quite elaborate mechanisms, usually embodying some sort of cam, are often required. Two cases where quite simple cam devices accomplish the purpose are the operations of oil-grooving the bearings in the saddle and on the upper index wheel of the Fellows gear shaper.

The oil-groove in the saddle bearing consists of three circular and three helical grooves, as shown in Fig. 1. The helical grooves run into the circular ones near their ends, further complicating the machining. This saddle bearing takes the ram carrying the cutter-spindle and is the most important and most used bearing on the machine. The up-and-down sliding motion to which it is constantly subjected takes place at fairly high speeds. The necessity for smooth-edged grooves, giving an even and ample distribution of oil, is obvious. The ram has a rack cut on the rear side from which it receives its motion. The bearing is therefore not circular, but has about one-third cut away as shown.

A simple but effective device for cutting these grooves was made by mounting a cam in the boring-bar of a horizontal

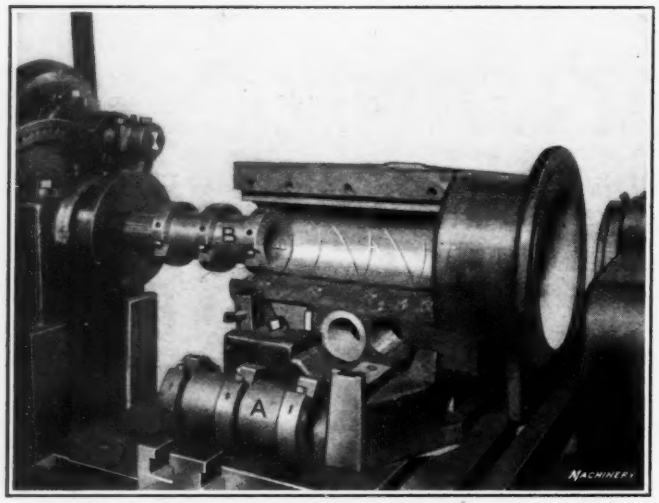



Fig. 1. Tools for cutting Oil-grooves in Gear Shaper Saddle

boring mill. The cam is shown in position in Fig. 2. The machining of the grooves is done in two operations, using the two sets of grooving tools *A* and *B*, Fig. 1. The three circular grooves are cut in one operation with the tool *A*, the cam being removed from the boring-bar. The center of the work is set horizontal with the center of the boring-bar and the table fed forward, bringing the work into the tool. The depth of the grooves is 0.120 inch. For the helical grooves, tool *B* is used; this has the three cutters ground to the helix angle of the grooves. The cam, mounted on the boring-bar, carries the cutters along the helical path of the grooves, then in a circular path for about 15 degrees where the helical grooves run into the circular ones, after which they are given a quick-return helical motion while sweeping over the part of the bearing which is cut away. The table is fed forward during the last part of the revolution, when the cut is repeated until the desired depth of groove is reached. The stationary roller *R*, Fig. 2, running in the cam groove, gives the boring-bar its endwise motion. The cutting time for each grooving operation is one and one-half minute. The aligning jig used is the same as is used for boring the saddles.

The external grooving on the upper index wheel is done by the application of a similar mechanism to the engine lathe; Fig. 3 shows the arrangement. The oil-grooves in this case are four simple helical grooves running backward and forward

[1]Address: Industrial Department, Springfield High School, Springfield, Vt.

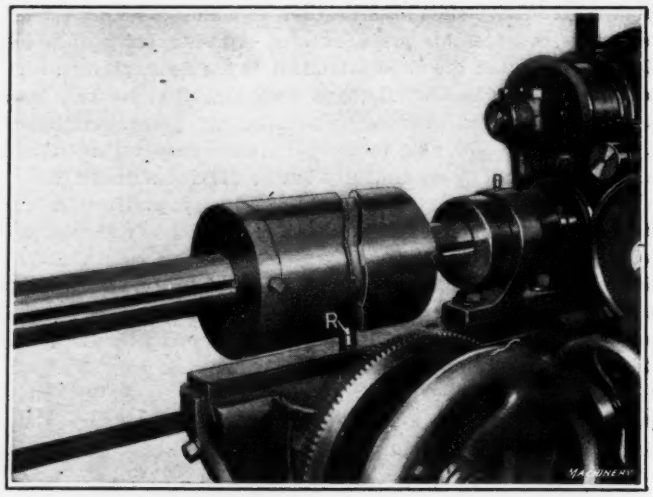



Fig. 2. Cam controlling machining of Helical Oil-grooves in Saddle

around the hub of the index wheel. The tool used for cutting them is a common grooving tool. The cam *C*, Fig. 3, is mounted on the feed-rod of the lathe; the bracket *B* holds the roller, which runs in the cam groove. The lathe feed is disconnected and the motion of the carriage is controlled entirely by the cam. The cam groove has only two lobes, but the lathe is geared so that the feed-rod makes two revolutions while the work makes one, so that the groove in the work has four lobes. The cutting time for this operation is about two minutes.

* * *

The tendency of manufacturing concerns during the past twenty years has been to establish their plants outside of cities and towns where land is cheap and free from the restrictions imposed on city property. From the engineering point of view, the location outside was advantageous. Large plants could be built one story high, using the sawtooth roof construction which provides for unlimited expansion and uniform daylight throughout. But from the labor point of view, such locations have serious objections. A large plant on the outskirts of a town may, and usually does, draw its labor supply from various sections of the town, and some of the employes will be on the far side, thus making necessary long car rides morning and night. There is a growing reversion to the multiple-story type building located nearer the center of local population, where it may be reached without long trips on the street cars.

* * *

A centrifugal machine for casting iron pipe has been developed by a Brazilian named J. J. Queioz, which casts pipe in permanent molds without cores. The molten metal is poured into the machine through a horizontal trough, from which it is discharged into the revolving mold. The mold is water-cooled and the pipe quickly sets so that it can be removed. It is claimed that the process is rapid, economical and that the product is superior to cast-iron pipe cast in sand molds.

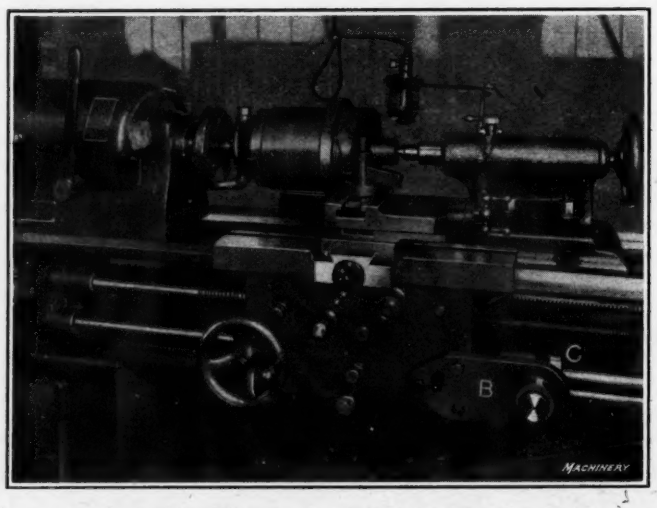



Fig. 3. Cutting Oil-grooves in Upper Index Wheel in a Lathe

THE production of screw threads on an interchangeable basis is one of the most difficult problems encountered in applying the limit system. In a report presented to the American Society of Mechanical Engineers in April, 1912, several interesting questions in connection with this subject were brought up for discussion, but up to the present time the committee handling this matter has not presented a full report. Considerable difference of opinion exists in regard to the question of manufacturing tolerances on the various elements of a screw thread, and in the following this point, as well as several others of importance, will be reviewed.

### Elements of Screw Threads

The elements of a screw thread are indicated in Fig. 1, and the following gives a list of the various names used to define the particular point or element of the thread referred to:

*A* is the pitch diameter of a screw and is measured by the distance between the pitch lines, which are located where the width of the land and the space are the same and equal to one-half the pitch. This element is also known as the angle diameter and the effective diameter.

*B* is the outside diameter of a screw and is twice the maximum radius of the screw measured at right angles to the axis. This element is also known as the full diameter and the external diameter.

*C* is the smallest diameter of a screw thread and is equal to twice the minimum radius of the screw measured at right angles to the axis. This element is known as the root diameter and the core diameter.

*D* is the pitch and is the distance between the centers of any two adjacent threads, measured parallel with the axis of the screw. The reciprocal of the pitch measures the number of turns per inch; therefore *D* is correctly expressed in fractions, for instance as ½ inch, but is commonly expressed as the number of threads per inch.

*E* is the included angle of the thread and refers to the angle between the slopes of the thread measured in an axial plane.

*F* is the slope of a thread and refers to the angular side of the thread which connects the crest and root.

*G* is the crest or prominent part of the thread, whether of the male screw or female nut. This part is also known as the top and the flat on U. S. standard form of threads.

*H* is the root, and refers to the bottom of the groove of the thread, whether of the male screw or of the female nut. This element is also known as the bottom.

The dimension *C* on the male thread or screw is measured at the root of the thread, whereas the same dimension on the female thread or nut is measured between the crests. These two dimensions are practically the same except for the allowance made for clearance. The lead of the screw is the distance that it travels in a longitudinal direction in one turn and differs from the pitch in that the latter measures the distance from center to center of any two adjacent threads.

In the case of the standard V-thread, shown at *A* in Fig. 2, there are five points to be measured in both the screw and the nut, making a total of ten in all. An error in any one of these points will prevent the screw and nut from going together properly. In the Cadillac form of thread, shown at *B*, four of these points are eliminated, leaving only the pitch diameter, pitch, and angle of thread to be considered on the screw and the nut.

Theoretically, the shape of the threads shown at *C*, *D* and *E* in Fig. 2 present ten elements that must be correct before the screw and nut will go together properly. The Acme thread, shown at *F*, has a clearance top and bottom, leaving only six out of the ten elements to be considered. In actual practice, the U. S. standard form of thread is made with a clearance top and bottom, and the chief points are to have the thread correct on the angular faces and the pitch and the pitch diameter correct. The tolerances, however, have never been generally accepted, and it is for this reason that so much uncertainty exists as to tolerances that should be given on threaded parts for various classes of work.

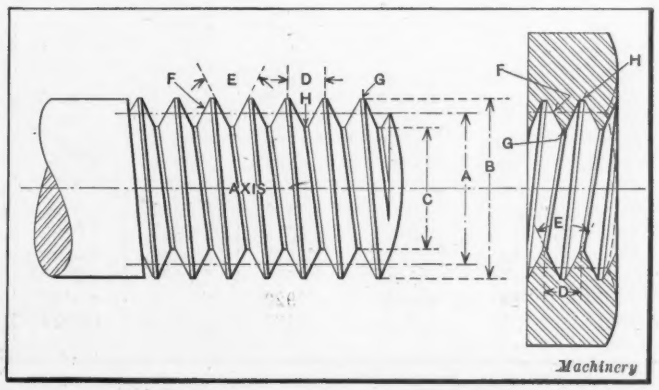



Fig. 1. Diagram illustrating Various Elements of a Screw Thread

### Tolerances on Screw Threads

The three points that receive the most careful attention in the production of a screw thread are the pitch,

[1] For information on gages and gaging previously published in MACHINERY, see "Profile and Indicating Gages" in the November and December, 1916, numbers and articles referred to in connection with the first installment.

[2] Address: Fellows Gear Shaper Co., Springfield, Vt.

the pitch diameter, and the included angle of the thread. In the U. S. standard thread, errors in pitch can be corrected by reducing the pitch diameter by an amount equal to about one and one-half times the error in pitch on the radius, or about three times the pitch error on the full diameter of the screw. In threaded parts that must fit together, however, this method of obtaining a fit is not recommended.

The permissible error in lead is dependent upon the length of the thread on the screw or in the nut. The longer the screws or the deeper the holes in the nut, the smaller will be the amount of error permissible in the lead. Another factor that must be considered in fitting a screw and a nut is the included angle of the thread. This element can be compensated for by a reduction or increase of the pitch diameter, depending upon whether the angle is greater or less than that required.

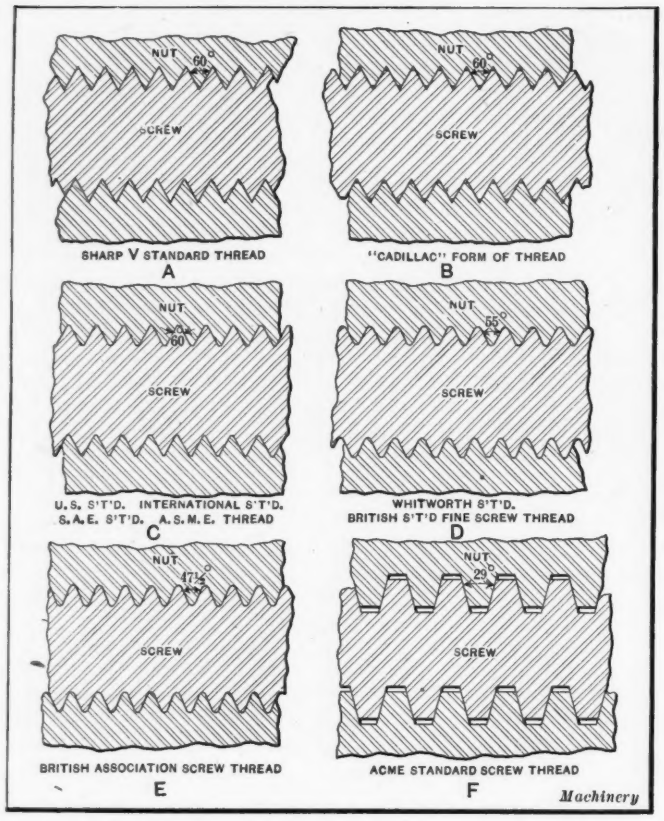



Fig. 2. Diagrams illustrating Various Forms of Screw Threads

The Engineering Standards Committee of Great Britain has given the subject of screw-thread tolerances considerable attention, and has established certain tolerances for different classes of fits. The formulas established for determining the tolerances and allowances on the outside and root diameters of the bolt and nut for the Whitworth and British standard fine screw threads are given in the following, and the data for the British standard Whitworth thread are also given in Tables I and II. The tolerances and allowances on the British standard Whitworth thread are found by the following formulas:

Tolerance on outside diameter of bolt $= -0.0035$ inch $\sqrt{D}$ (1)

Tolerance on root diameter of bolt $= -0.0045$ inch $\sqrt{D}$ (2)

Tolerance between bolt and nut $= +0.001$ inch $\sqrt{D}$ (3)

Tolerance on outside and root diameters of nut $= +0.0035$ inch $\sqrt{D}$ (4)

in which $D$ = nominal diameter of the thread in inches.

The positive and negative signs refer to the direction in which the tolerance is permitted on the bolt and nut, respectively. The tolerance on the outside and root diameters of the nut established by Formula (4) is to be added to the allowance given by Formula (3).

The formulas used for determining the tolerances and allowances on British standard fine threads are as follows:

Tolerance on outside diameter of bolt $= -0.0025$ inch $\sqrt{D}$ (5)

Tolerance on root diameter of bolt $= -0.0035$ inch $\sqrt{D}$ (6)

Allowance of nut $= +0.001$ inch $\sqrt{D}$ (7)

Tolerance on outside and root diameters of nut $= +0.0025$ inch $\sqrt{D}$ (8)

The amount established by Formula (8) is also to be added to that obtained by Formula (7).

## TABLE I. BRITISH STANDARD WHITWORTH SCREW THREADS—TOLERANCES FOR BOLTS

| Nominal Diameter of Screw, Inches | Number of Threads per Inch | Tolerance on Pitch per Inch Length of Thread, Inches | Outside Diameter, Inches | | | Pitch Diameter, Inches | | | Root Diameter, Inches | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Maximum | Minimum | Tolerance | Max. for a Screw of Correct Pitch[1] | Minimum | Tolerance | Maximum | Minimum | Tolerance |
| 1/4 | 20.0 | 0.0035 | 0.2500 | 0.2482 | 0.0018 | 0.2180 | 0.2162 | 0.0018 | 0.1860 | 0.1837 | 0.0023 |
| 5/16 | 18.0 | 0.0033 | 0.3125 | 0.3105 | 0.0020 | 0.2769 | 0.2748 | 0.0021 | 0.2414 | 0.2389 | 0.0025 |
| 3/8 | 16.0 | 0.0032 | 0.3750 | 0.3729 | 0.0021 | 0.3350 | 0.3326 | 0.0024 | 0.2950 | 0.2922 | 0.0028 |
| 7/16 | 14.0 | 0.0031 | 0.4375 | 0.4352 | 0.0023 | 0.3918 | 0.3891 | 0.0027 | 0.3460 | 0.3430 | 0.0030 |
| 1/2 | 12.0 | 0.0030 | 0.5000 | 0.4975 | 0.0025 | 0.4466 | 0.4436 | 0.0030 | 0.3933 | 0.3901 | 0.0032 |
| 9/16 | 12.0 | 0.0029 | 0.5625 | 0.5599 | 0.0026 | 0.5091 | 0.5059 | 0.0032 | 0.4558 | 0.4524 | 0.0034 |
| 5/8 | 11.0 | 0.0028 | 0.6250 | 0.6222 | 0.0028 | 0.5668 | 0.5633 | 0.0035 | 0.5086 | 0.5050 | 0.0036 |
| 11/16 | 11.0 | 0.0027 | 0.6875 | 0.6846 | 0.0029 | 0.6293 | 0.6255 | 0.0038 | 0.5711 | 0.5674 | 0.0037 |
| 3/4 | 10.0 | 0.0027 | 0.7500 | 0.7470 | 0.0030 | 0.6860 | 0.6820 | 0.0040 | 0.6219 | 0.6180 | 0.0039 |
| 13/16 | 10.0 | 0.0026 | 0.8125 | 0.8093 | 0.0032 | 0.7485 | 0.7442 | 0.0043 | 0.6844 | 0.6803 | 0.0041 |
| 7/8 | 9.0 | 0.0026 | 0.8750 | 0.8717 | 0.0033 | 0.8039 | 0.7994 | 0.0045 | 0.7327 | 0.7285 | 0.0042 |
| 15/16 | 9.0 | 0.0025 | 0.9375 | 0.9341 | 0.0034 | 0.8664 | 0.8616 | 0.0048 | 0.7952 | 0.7908 | 0.0044 |
| 1 | 8.0 | 0.0025 | 1.0000 | 0.9965 | 0.0035 | 0.9200 | 0.9150 | 0.0050 | 0.8399 | 0.8354 | 0.0045 |
| 1 1/8 | 7.0 | 0.0024 | 1.1250 | 1.1213 | 0.0037 | 1.0335 | 1.0280 | 0.0055 | 0.9420 | 0.9372 | 0.0048 |
| 1 1/4 | 7.0 | 0.0024 | 1.2500 | 1.2461 | 0.0039 | 1.1585 | 1.1526 | 0.0059 | 1.0670 | 1.0620 | 0.0050 |
| 1 3/8 | 6.0 | 0.0023 | 1.3750 | 1.3709 | 0.0041 | 1.2683 | 1.2620 | 0.0063 | 1.1616 | 1.1563 | 0.0053 |
| 1 1/2 | 6.0 | 0.0023 | 1.5000 | 1.4957 | 0.0043 | 1.3933 | 1.3865 | 0.0068 | 1.2866 | 1.2811 | 0.0055 |
| 1 5/8 | 5.0 | 0.0022 | 1.6250 | 1.6205 | 0.0045 | 1.4969 | 1.4897 | 0.0072 | 1.3689 | 1.3632 | 0.0057 |
| 1 3/4 | 5.0 | 0.0022 | 1.7500 | 1.7454 | 0.0046 | 1.6219 | 1.6143 | 0.0076 | 1.4939 | 1.4879 | 0.0060 |
| 1 7/8 | 4.5 | 0.0021 | 1.8750 | 1.8702 | 0.0048 | 1.7327 | 1.7247 | 0.0080 | 1.5904 | 1.5842 | 0.0062 |
| 2 | 4.5 | 0.0021 | 2.0000 | 1.9950 | 0.0050 | 1.8577 | 1.8493 | 0.0084 | 1.7154 | 1.7090 | 0.0064 |
| 2 1/8 | 4.5 | 0.0021 | 2.1250 | 2.1199 | 0.0051 | 1.9827 | 1.9739 | 0.0088 | 1.8404 | 1.8338 | 0.0066 |
| 2 1/4 | 4.0 | 0.0020 | 2.2500 | 2.2447 | 0.0053 | 2.0899 | 2.0807 | 0.0092 | 1.9298 | 1.9230 | 0.0068 |
| 2 3/8 | 4.0 | 0.0020 | 2.3750 | 2.3696 | 0.0054 | 2.2149 | 2.2053 | 0.0096 | 2.0548 | 2.0479 | 0.0069 |
| 2 1/2 | 4.0 | 0.0020 | 2.5000 | 2.4945 | 0.0055 | 2.3399 | 2.3300 | 0.0099 | 2.1798 | 2.1727 | 0.0071 |
| 2 5/8 | 4.0 | 0.0020 | 2.6250 | 2.6193 | 0.0057 | 2.4649 | 2.4546 | 0.0103 | 2.3048 | 2.2975 | 0.0073 |
| 2 3/4 | 3.5 | 0.0019 | 2.7500 | 2.7442 | 0.0058 | 2.5670 | 2.5563 | 0.0107 | 2.3841 | 2.3766 | 0.0075 |
| 2 7/8 | 3.5 | 0.0019 | 2.8750 | 2.8691 | 0.0059 | 2.6920 | 2.6810 | 0.0110 | 2.5091 | 2.5015 | 0.0076 |
| 3 | 3.5 | 0.0019 | 3.0000 | 2.9940 | 0.0060 | 2.8170 | 2.8056 | 0.0114 | 2.6341 | 2.6263 | 0.0078 |

Machinery

[1] The maximum pitch diameter is decreased when the screw is incorrect in pitch by the amount compensating for such error given in Table III.

## TABLE II. BRITISH STANDARD WHITWORTH SCREW THREADS—TOLERANCES FOR NUTS

| Nominal Diameter of Screw, Inches | Number of Threads per Inch | Tolerance on Pitch per Inch of Length of Thread, Inches | Outside Diameter, Inches | | | Pitch Diameter, Inches | | | Root Diameter, Inches | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Maximum | Minimum | Tolerance | Maximum | Min. for a Nut of Correct Pitch[1] | Tolerance | Maximum | Minimum | Tolerance |
| 1/4 | 20.0 | 0.0035 | 0.2523 | 0.2505 | 0.0018 | 0.2203 | 0.2185 | 0.0018 | 0.1883 | 0.1865 | 0.0018 |
| 5/16 | 18.0 | 0.0033 | 0.3151 | 0.3131 | 0.0020 | 0.2796 | 0.2775 | 0.0021 | 0.2440 | 0.2420 | 0.0020 |
| 3/8 | 16.0 | 0.0032 | 0.3777 | 0.3756 | 0.0021 | 0.3380 | 0.3356 | 0.0024 | 0.2977 | 0.2956 | 0.0021 |
| 7/16 | 14.0 | 0.0031 | 0.4405 | 0.4382 | 0.0023 | 0.3952 | 0.3925 | 0.0027 | 0.3490 | 0.3467 | 0.0023 |
| 1/2 | 12.0 | 0.0030 | 0.5032 | 0.5007 | 0.0025 | 0.4503 | 0.4473 | 0.0030 | 0.3965 | 0.3940 | 0.0025 |
| 9/16 | 12.0 | 0.0029 | 0.5659 | 0.5633 | 0.0026 | 0.5131 | 0.5099 | 0.0032 | 0.4592 | 0.4566 | 0.0026 |
| 5/8 | 11.0 | 0.0028 | 0.6286 | 0.6258 | 0.0028 | 0.5711 | 0.5676 | 0.0035 | 0.5122 | 0.5094 | 0.0028 |
| 11/16 | 11.0 | 0.0027 | 0.6912 | 0.6883 | 0.0029 | 0.6339 | 0.6301 | 0.0038 | 0.5748 | 0.5719 | 0.0029 |
| 3/4 | 10.0 | 0.0027 | 0.7539 | 0.7509 | 0.0030 | 0.6909 | 0.6869 | 0.0040 | 0.6258 | 0.6228 | 0.0030 |
| 13/16 | 10.0 | 0.0026 | 0.8166 | 0.8134 | 0.0032 | 0.7537 | 0.7494 | 0.0043 | 0.6885 | 0.6853 | 0.0032 |
| 7/8 | 9.0 | 0.0026 | 0.8792 | 0.8759 | 0.0033 | 0.8093 | 0.8048 | 0.0045 | 0.7369 | 0.7336 | 0.0033 |
| 15/16 | 9.0 | 0.0025 | 0.9419 | 0.9385 | 0.0034 | 0.8722 | 0.8674 | 0.0048 | 0.7996 | 0.7962 | 0.0034 |
| 1 | 8.0 | 0.0025 | 1.0045 | 1.0010 | 0.0035 | 0.9260 | 0.9210 | 0.0050 | 0.8444 | 0.8409 | 0.0035 |
| 1 1/8 | 7.0 | 0.0024 | 1.1298 | 1.1261 | 0.0037 | 1.0401 | 1.0346 | 0.0055 | 0.9468 | 0.9431 | 0.0037 |
| 1 1/4 | 7.0 | 0.0024 | 1.2550 | 1.2511 | 0.0039 | 1.1655 | 1.1596 | 0.0059 | 1.0720 | 1.0681 | 0.0039 |
| 1 3/8 | 6.0 | 0.0023 | 1.3803 | 1.3762 | 0.0041 | 1.2758 | 1.2695 | 0.0063 | 1.1669 | 1.1628 | 0.0041 |
| 1 1/2 | 6.0 | 0.0023 | 1.5055 | 1.5012 | 0.0043 | 1.4013 | 1.3945 | 0.0068 | 1.2921 | 1.2878 | 0.0043 |
| 1 5/8 | 5.0 | 0.0022 | 1.6308 | 1.6263 | 0.0045 | 1.5054 | 1.4982 | 0.0072 | 1.3747 | 1.3702 | 0.0045 |
| 1 3/4 | 5.0 | 0.0022 | 1.7559 | 1.7513 | 0.0046 | 1.6308 | 1.6232 | 0.0076 | 1.4998 | 1.4952 | 0.0046 |
| 1 7/8 | 4.5 | 0.0021 | 1.8812 | 1.8764 | 0.0048 | 1.7421 | 1.7341 | 0.0080 | 1.5966 | 1.5918 | 0.0048 |
| 2 | 4.5 | 0.0021 | 2.0064 | 2.0014 | 0.0050 | 1.8675 | 1.8591 | 0.0084 | 1.7218 | 1.7168 | 0.0050 |
| 2 1/8 | 4.5 | 0.0021 | 2.1316 | 2.1265 | 0.0051 | 1.9930 | 1.9842 | 0.0088 | 1.8470 | 1.8419 | 0.0051 |
| 2 1/4 | 4.0 | 0.0020 | 2.2568 | 2.2515 | 0.0053 | 2.1006 | 2.0914 | 0.0092 | 1.9366 | 1.9313 | 0.0053 |
| 2 3/8 | 4.0 | 0.0020 | 2.3819 | 2.3765 | 0.0054 | 2.2260 | 2.2164 | 0.0096 | 2.0617 | 2.0563 | 0.0054 |
| 2 1/2 | 4.0 | 0.0020 | 2.5071 | 2.5016 | 0.0055 | 2.3514 | 2.3415 | 0.0099 | 2.1869 | 2.1814 | 0.0055 |
| 2 5/8 | 4.0 | 0.0020 | 2.6323 | 2.6266 | 0.0057 | 2.4768 | 2.4665 | 0.0103 | 2.3121 | 2.3064 | 0.0057 |
| 2 3/4 | 3.5 | 0.0019 | 2.7575 | 2.7517 | 0.0058 | 2.5794 | 2.5687 | 0.0107 | 2.3916 | 2.3858 | 0.0058 |
| 2 7/8 | 3.5 | 0.0019 | 2.8826 | 2.8767 | 0.0059 | 2.7047 | 2.6937 | 0.0110 | 2.5167 | 2.5108 | 0.0059 |
| 3 | 3.5 | 0.0019 | 3.0077 | 3.0017 | 0.0060 | 2.8301 | 2.8187 | 0.0114 | 2.6418 | 2.6358 | 0.0060 |

*Machinery*

[1] The minimum pitch diameter is increased when the nut is incorrect in pitch by the amount compensating for such error given in Table III.

### Tolerances on Pitch and Pitch Diameter

In regard to errors in pitch and pitch diameter, it should be understood that with an angular thread the error in pitch manifests itself not only in the direction of the axis of the screw, but also at right angles to the axis. Therefore if an error in pitch is tolerated, a corresponding allowance should be made in the pitch diameter to compensate for the transverse effect of the pitch error introduced. If the limits for pitch diameter are determined by Formulas (11) and (12), respectively, which are intended to cover both the errors of that element and the allowance required to compensate for the transverse effect of pitch error, it follows that the error in pitch must be limited to such an amount that the corresponding allowance in pitch diameter is never greater than the tolerances given.

The maximum permissible error in pitch, which as previously explained is connected with the tolerance on the pitch diameter, is determined by the following formulas, the thickness of the nut being assumed to be equal to the diameter of the bolt.

Tolerance in pitch per inch of length of thread in nut for

$$\text{British standard Whitworth thread} = \frac{\pm 0.0025}{\sqrt[4]{D}} \qquad (9)$$

Tolerance in pitch per inch of length of thread in nut for

$$\text{British standard fine screw threads} = \frac{\pm 0.0015}{\sqrt[4]{D}} \qquad (10)$$

Applying Formula (9) for a British standard Whitworth ¼-inch bolt, the actual error permissible in the length of thread in the nut will be found to be less than ± 0.001 inch.

The tolerances on the pitch diameter, which include in each case the allowances made to compensate for the maximum pitch error, are determined by the formulas given in the following:

Tolerance on pitch diameter of British standard Whitworth thread $= 0.005 \sqrt[4]{D^3}$ (11)

Tolerance on pitch diameter of British standard fine threads $= 0.003 \sqrt[4]{D^3}$ (12)

### TABLE III. ALLOWANCES TO COMPENSATE FOR ERRORS IN PITCH OF BRITISH STANDARD WHITWORTH SCREW THREADS

| Nominal Diameter of Screw, Inches | Allowances in Pitch Diameter to Compensate for Errors in Pitch of | | | | | | |
|---|---|---|---|---|---|---|---|
| | ± 0.0005 Inch per Inch | ± 0.0010 Inch per Inch | ± 0.0015 Inch per Inch | ± 0.0020 Inch per Inch | ± 0.0025 Inch per Inch | ± 0.0030 Inch per Inch | ± 0.0035 Inch per Inch |
| 1/4 | 0.0003 | 0.0005 | 0.0008 | 0.0010 | 0.0013 | 0.0015 | 0.0018 |
| 5/16 | 0.0003 | 0.0006 | 0.0009 | 0.0013 | 0.0016 | 0.0019 | 0.0022 |
| 3/8 | 0.0004 | 0.0008 | 0.0011 | 0.0015 | 0.0019 | 0.0023 | 0.0026 |
| 7/16 | 0.0004 | 0.0009 | 0.0013 | 0.0018 | 0.0022 | 0.0026 | 0.0031 |
| 1/2 | 0.0005 | 0.0010 | 0.0015 | 0.0020 | 0.0025 | 0.0030 | ..... |
| 9/16 | 0.0006 | 0.0011 | 0.0017 | 0.0023 | 0.0028 | 0.0034 | ..... |
| 5/8 | 0.0006 | 0.0013 | 0.0019 | 0.0025 | 0.0031 | 0.0038 | ..... |
| 11/16 | 0.0007 | 0.0014 | 0.0021 | 0.0028 | 0.0034 | 0.0041 | ..... |
| 3/4 | 0.0008 | 0.0015 | 0.0023 | 0.0030 | 0.0038 | 0.0045 | ..... |
| 13/16 | 0.0008 | 0.0016 | 0.0024 | 0.0033 | 0.0041 | 0.0049 | ..... |
| 7/8 | 0.0009 | 0.0018 | 0.0026 | 0.0035 | 0.0044 | 0.0053 | ..... |
| 15/16 | 0.0009 | 0.0019 | 0.0028 | 0.0038 | 0.0047 | ..... | ..... |
| 1 | 0.0010 | 0.0020 | 0.0030 | 0.0040 | 0.0050 | ..... | ..... |
| 1 1/8 | 0.0011 | 0.0023 | 0.0034 | 0.0045 | 0.0056 | ..... | ..... |
| 1 1/4 | 0.0013 | 0.0025 | 0.0038 | 0.0050 | 0.0063 | ..... | ..... |
| 1 3/8 | 0.0014 | 0.0028 | 0.0041 | 0.0055 | 0.0069 | ..... | ..... |
| 1 1/2 | 0.0015 | 0.0030 | 0.0045 | 0.0060 | 0.0075 | ..... | ..... |
| 1 5/8 | 0.0016 | 0.0033 | 0.0049 | 0.0065 | 0.0081 | ..... | ..... |
| 1 3/4 | 0.0018 | 0.0035 | 0.0053 | 0.0070 | 0.0088 | ..... | ..... |
| 1 7/8 | 0.0019 | 0.0038 | 0.0056 | 0.0075 | 0.0094 | ..... | ..... |
| 2 | 0.0020 | 0.0040 | 0.0060 | 0.0080 | 0.0100 | ..... | ..... |
| 2 1/8 | 0.0021 | 0.0043 | 0.0064 | 0.0085 | 0.0106 | ..... | ..... |
| 2 1/4 | 0.0023 | 0.0045 | 0.0068 | 0.0090 | ..... | ..... | ..... |
| 2 3/8 | 0.0024 | 0.0048 | 0.0071 | 0.0095 | ..... | ..... | ..... |
| 2 1/2 | 0.0025 | 0.0050 | 0.0075 | 0.0100 | ..... | ..... | ..... |
| 2 5/8 | 0.0026 | 0.0053 | 0.0079 | 0.0105 | ..... | ..... | ..... |
| 2 3/4 | 0.0028 | 0.0055 | 0.0083 | 0.0110 | ..... | ..... | ..... |
| 2 7/8 | 0.0029 | 0.0058 | 0.0086 | 0.0115 | ..... | ..... | ..... |
| 3 | 0.0030 | 0.0060 | 0.0090 | 0.0120 | ..... | ..... | ..... |

*Machinery*

In the case of a bolt of incorrect pitch, the pitch diameter must be reduced by the amount necessary to compensate for the pitch error; that is, the pitch diameter requires an allowance for this purpose. Thus the tolerances on the pitch diameter and pitch are linked together, so that if the pitch is correct the tolerance on the pitch diameter has the full value given in Table I, but if the pitch is in error, the permissible limits or variations in pitch diameter are reduced by the allowance given in Table III. In the case of a nut, the minimum pitch diameter is increased by the allowance given in Table III.

For instance, in the case of bolts having a known pitch error, the maximum pitch diameter given in Table I must be decreased an amount equal to that given in Table III, the minimum pitch diameter remaining the same. For example, in calculating the amount of allowance necessary in the pitch diameter for a British Whitworth 1-inch bolt having, say, a pitch error of + 0.0012 inch per inch, the amount of compensation, as found by interpolation from Table III, is 0.0024 inch; so that the limits on the pitch diameter of the bolt are:

Maximum pitch diameter = 0.9200 — 0.0024 = 0.9176 inch;

Minimum pitch diameter (unchanged) = 0.9150 inch.

While for a 1-inch British Whitworth nut having the same pitch error, the changes in the pitch diameter are:

Maximum pitch diameter (unchanged) = 0.9260 inch;

Minimum pitch diameter = 0.9210 + 0.0024 = 0.9234 inch.

TABLE IV. TOLERANCES ON INCLUDED ANGLE OF SCREW THREADS (THE ENGINEERING STANDARDS COMMITTEE)

| Form of Thread | Range of Size, Nominal Diameter, Inches | Tolerance on Included Angle, Degrees |
|---|---|---|
| British Standard Whitworth Thread | 1/4 to 9/16 | ± 1.5 |
| | 5/8 to 2 1/8 | ± 1.0 |
| | 2 1/4 to 3 | ± 0.5 |
| British Standard Fine Thread | 1/4 to 13/16 | ± 1.5 |
| | 7/8 to 3 | ± 1.0 |

*Machinery*

### Tolerances on Included Angle of Thread

As has been mentioned, the included angle of the thread ranks in importance with the pitch and the pitch diameter. Errors in angle can be such as to prevent interchangeability, so that it is necessary to establish limits for the included angle of the thread. The tolerances on British standard Whitworth and British standard fine threads are given in Table IV. Reference to this table will show that the coarser the pitch, the smaller is the permissible error in the included angle. The reason for this is that a coarser pitch has a greater amount of thread surface in contact than a finer pitch, and consequently must be made to closer limits.

TABLE V. TOLERANCES ON PITCH DIAMETERS OF U. S. STANDARD SCREWS, TAPS AND GAGES (LOOSE FIT TOLERANCES)

| Nominal Diameter of Screw, Inches | Number of Threads per Inch | Basic or Pitch Dia. of Max. Screw | Pitch Diam. of Min. Screw | Tolerance between Max. and Min. Pitch Diam. of Screw | Tolerance between Max. Screw and Min. Pitch Dia. of Tap | Tapped Hole, Pitch Diameter | | Tolerance on Tapped Hole | Gage, Pitch Diameter | | Difference between "Go" and "Not Go" Ends of Gage | Difference between Min. Gage and Max. Screw |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Max. | Min. | | Max. | Min. | | |
| 1/4 | 20 | 0.2175 | 0.2160 | 0.0015 | 0.0005 | 0.2200 | 0.2180 | 0.0020 | 0.22020 | 0.21820 | 0.0020 | 0.00070 |
| 5/16 | 18 | 0.2764 | 0.2748 | 0.0016 | 0.0006 | 0.2790 | 0.2770 | 0.0020 | 0.27920 | 0.27720 | 0.0020 | 0.00080 |
| 3/8 | 16 | 0.3344 | 0.3327 | 0.0017 | 0.0006 | 0.3380 | 0.3350 | 0.0030 | 0.33820 | 0.33520 | 0.0030 | 0.00080 |
| 7/16 | 14 | 0.3911 | 0.3892 | 0.0019 | 0.0009 | 0.3950 | 0.3920 | 0.0030 | 0.39520 | 0.39220 | 0.0030 | 0.00110 |
| 1/2 | 13 | 0.4501 | 0.4481 | 0.0020 | 0.0009 | 0.4540 | 0.4510 | 0.0030 | 0.45420 | 0.45120 | 0.0030 | 0.00110 |
| 9/16 | 12 | 0.5084 | 0.5063 | 0.0021 | 0.0010 | 0.5124 | 0.5094 | 0.0030 | 0.51260 | 0.50960 | 0.0030 | 0.00120 |
| 5/8 | 11 | 0.5660 | 0.5638 | 0.0022 | 0.0010 | 0.5700 | 0.5670 | 0.0030 | 0.57020 | 0.56720 | 0.0030 | 0.00120 |
| 11/16 | 11 | 0.6285 | 0.6262 | 0.0023 | 0.0010 | 0.6325 | 0.6295 | 0.0030 | 0.63270 | 0.62970 | 0.0030 | 0.00120 |
| 3/4 | 10 | 0.6851 | 0.6827 | 0.0024 | 0.0010 | 0.6901 | 0.6861 | 0.0040 | 0.69030 | 0.68630 | 0.0040 | 0.00120 |
| 13/16 | 10 | 0.7476 | 0.7451 | 0.0025 | 0.0010 | 0.7526 | 0.7486 | 0.0040 | 0.75280 | 0.74880 | 0.0040 | 0.00120 |
| 7/8 | 9 | 0.8029 | 0.8004 | 0.0025 | 0.0011 | 0.8080 | 0.8040 | 0.0040 | 0.80820 | 0.80420 | 0.0040 | 0.00130 |
| 15/16 | 9 | 0.8654 | 0.8627 | 0.0027 | 0.0011 | 0.8705 | 0.8665 | 0.0040 | 0.87070 | 0.86670 | 0.0040 | 0.00130 |
| 1 | 8 | 0.9188 | 0.9159 | 0.0029 | 0.0012 | 0.9270 | 0.9220 | 0.0050 | 0.92725 | 0.92025 | 0.0050 | 0.00145 |
| 1 1/8 | 7 | 1.0322 | 1.0292 | 0.0030 | 0.0012 | 1.0384 | 1.0334 | 0.0050 | 1.03865 | 1.03365 | 0.0050 | 0.00145 |
| 1 1/4 | 7 | 1.1572 | 1.1541 | 0.0031 | 0.0012 | 1.1634 | 1.1584 | 0.0050 | 1.16365 | 1.15865 | 0.0050 | 0.00145 |
| 1 3/8 | 6 | 1.2668 | 1.2635 | 0.0033 | 0.0013 | 1.2741 | 1.2681 | 0.0060 | 1.27435 | 1.26835 | 0.0060 | 0.00155 |
| 1 1/2 | 6 | 1.3918 | 1.3884 | 0.0034 | 0.0013 | 1.3991 | 1.3931 | 0.0060 | 1.39935 | 1.39335 | 0.0060 | 0.00155 |

*Machinery*

TABLE VI. TOLERANCES ON PITCH DIAMETERS OF U. S. STANDARD SCREWS, TAPS AND GAGES (CLOSE FIT TOLERANCES)

| Nominal Diameter of Screw, Inches | Number of Threads per Inch | Basic or Pitch Dia. of Max. Screw | Pitch Diam. of Min. Screw | Tolerance between Max. and Min. Pitch Diam. of Screw | Tolerance between Max. Screw and Min. Pitch Dia. of Tap | Tapped Hole, Pitch Diameter | | Tolerance on Tapped Hole | Gage, Pitch Diameter | | Difference between "Go" and "Not Go" Ends of Gage | Difference between Min. Gage and Max. Screw |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Max. | Min. | | Max. | Min. | | |
| 1/4 | 20 | 0.2175 | 0.2160 | 0.0015 | 0.0005 | 0.2190 | 0.2180 | 0.0010 | 0.21920 | 0.21820 | 0.0010 | 0.00070 |
| 5/16 | 18 | 0.2764 | 0.2748 | 0.0016 | 0.0006 | 0.2780 | 0.2770 | 0.0010 | 0.27820 | 0.27720 | 0.0010 | 0.00080 |
| 3/8 | 16 | 0.3344 | 0.3327 | 0.0017 | 0.0006 | 0.3365 | 0.3350 | 0.0015 | 0.33670 | 0.33520 | 0.0015 | 0.00080 |
| 7/16 | 14 | 0.3911 | 0.3892 | 0.0019 | 0.0009 | 0.3935 | 0.3920 | 0.0015 | 0.39370 | 0.39220 | 0.0015 | 0.00110 |
| 1/2 | 13 | 0.4501 | 0.4481 | 0.0020 | 0.0009 | 0.4525 | 0.4510 | 0.0015 | 0.45270 | 0.45120 | 0.0015 | 0.00110 |
| 9/16 | 12 | 0.5084 | 0.5063 | 0.0021 | 0.0010 | 0.5109 | 0.5094 | 0.0015 | 0.51110 | 0.50960 | 0.0015 | 0.00120 |
| 5/8 | 11 | 0.5660 | 0.5638 | 0.0022 | 0.0010 | 0.5685 | 0.5670 | 0.0015 | 0.56870 | 0.56720 | 0.0015 | 0.00120 |
| 11/16 | 11 | 0.6285 | 0.6262 | 0.0023 | 0.0010 | 0.6310 | 0.6295 | 0.0015 | 0.63120 | 0.62970 | 0.0015 | 0.00120 |
| 3/4 | 10 | 0.6851 | 0.6827 | 0.0024 | 0.0010 | 0.6881 | 0.6861 | 0.0020 | 0.68830 | 0.68630 | 0.0020 | 0.00120 |
| 13/16 | 10 | 0.7476 | 0.7451 | 0.0025 | 0.0010 | 0.7506 | 0.7486 | 0.0020 | 0.75080 | 0.74880 | 0.0020 | 0.00120 |
| 7/8 | 9 | 0.8029 | 0.8004 | 0.0025 | 0.0011 | 0.8060 | 0.8040 | 0.0020 | 0.80620 | 0.80420 | 0.0020 | 0.00130 |
| 15/16 | 9 | 0.8654 | 0.8627 | 0.0027 | 0.0011 | 0.8685 | 0.8665 | 0.0020 | 0.86870 | 0.86670 | 0.0020 | 0.00130 |
| 1 | 8 | 0.9188 | 0.9159 | 0.0029 | 0.0012 | 0.9225 | 0.9200 | 0.0025 | 0.92275 | 0.92025 | 0.0025 | 0.00145 |
| 1 1/8 | 7 | 1.0322 | 1.0292 | 0.0030 | 0.0012 | 1.0359 | 1.0334 | 0.0025 | 1.03615 | 1.03365 | 0.0025 | 0.00145 |
| 1 1/4 | 7 | 1.1572 | 1.1541 | 0.0031 | 0.0012 | 1.1609 | 1.1584 | 0.0025 | 1.16115 | 1.15865 | 0.0025 | 0.00145 |
| 1 3/8 | 6 | 1.2668 | 1.2635 | 0.0033 | 0.0013 | 1.2711 | 1.2681 | 0.0030 | 1.27135 | 1.26835 | 0.0030 | 0.00155 |
| 1 1/2 | 6 | 1.3918 | 1.3884 | 0.0034 | 0.0013 | 1.3961 | 1.3931 | 0.0030 | 1.39635 | 1.39335 | 0.0030 | 0.00155 |

*Machinery*

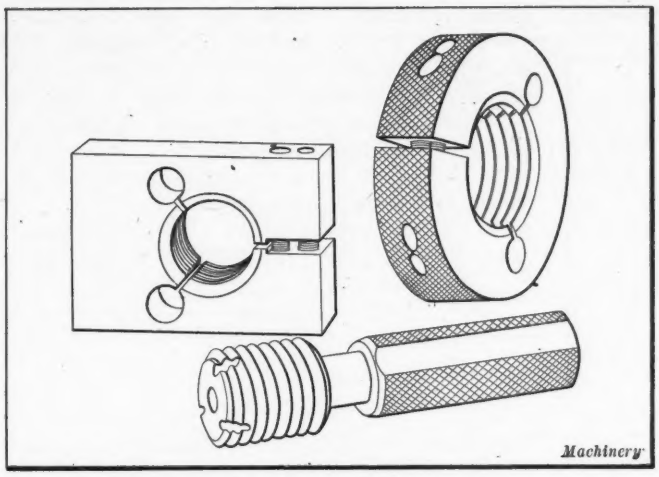



Fig. 3. Reference Thread Gages

### Tolerances on U. S. Standard Screw Threads

As mentioned, the committee appointed by the American Society of Mechanical Engineers to study the subject of tolerances on screw threads has not furnished a complete report. Several concerns, however, have adopted tolerances for their own use, some of which have been compiled and put into convenient form. Table V gives tolerances for U. S. standard screws and gages for loose fits, and Table VI gives those for close fits. Reference to these two tables will show that the tolerances on the tapped hole and the tolerances on the pitch diameter of the gage are the only two factors that are materially changed. The loose-fit limits are, in most cases, twice the close-fit limits. It will also be noticed that the manufacturing tolerances on the pitch diameter of the gage are given as 0.0002 inch up to 1 inch diameter and as 0.00025 inch for

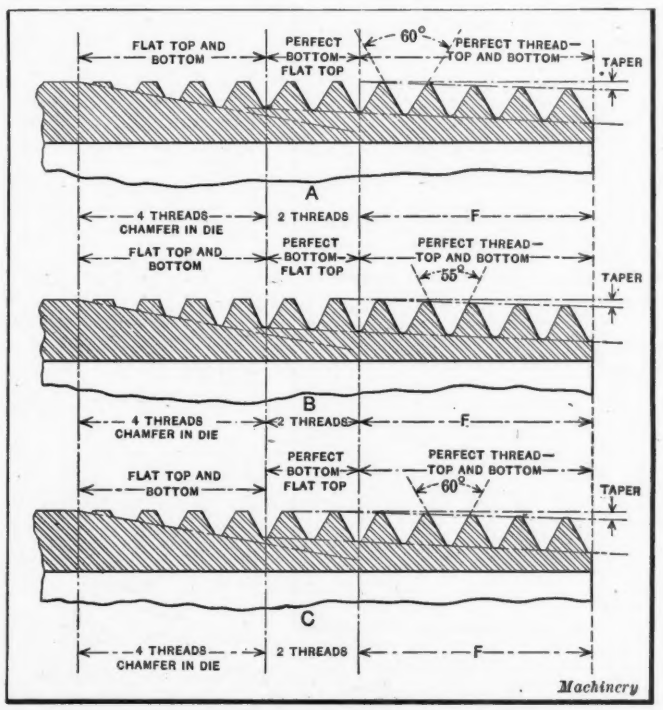



Fig. 4. Briggs and Whitworth Standard Forms of Pipe Threads; also Modified Briggs Standard Form

1 inch and over. The gage pitch diameters are made greater than the diameter of the maximum and minimum tapped holes, so as to provide for wear, especially on the "Go" end of the gage, as will be described later.

### Manufacturing Tolerances on Reference Thread Gages

In the measurement and inspection of threaded parts even greater care is necessary than in gaging a plain hole or shaft. The chief reason for this is that a thread has so many elements that must be taken into consideration that a careful study of the conditions to be met is necessary. Master or reference screw gages should be made much more accurately than working or inspection gages; and owing to this fact, master gages, as a rule, are left soft in order to eliminate any chance for warpage or shrinkage in hardening.

For reference thread gages, the tolerances in pitch are generally given per inch of length of thread and vary from 0.0005 inch per inch for pitches greater than ten threads per inch to 0.001 inch per inch for finer pitches. The tolerance on the pitch diameter, as has been mentioned, is also governed to a certain extent by the tolerance on the pitch. Most manufacturers, however, endeavor to hold the pitch diameter to

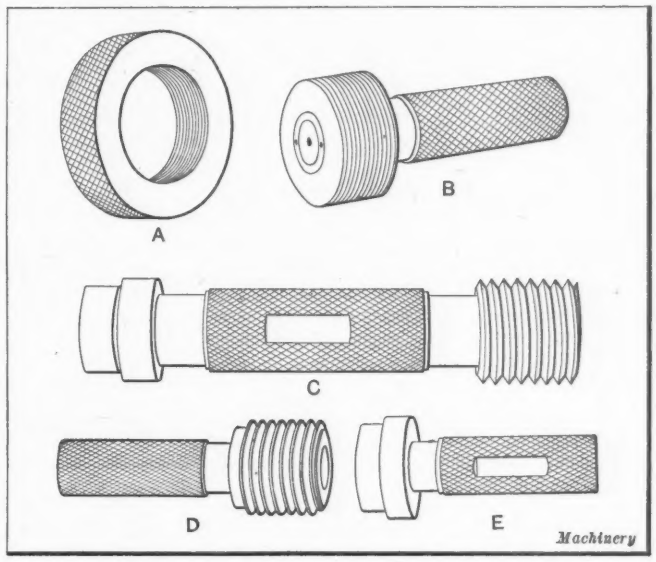



Fig. 5. Various Forms of Reference Gages for Whitworth Standard Threads

tolerances of ± 0.0001 inch. If the error in pitch is uniform, that is, equally distributed for the length of the thread, the tolerance on the pitch diameter can be held very close. For example, on a 10-pitch gage the error of 0.0005 inch is distributed over ten threads, making the average error in pitch only 0.00005 inch.

The included angle of the thread is one of the three elements that affect the pitch diameter in a similar manner to the pitch, and where close tolerances are adhered to on the

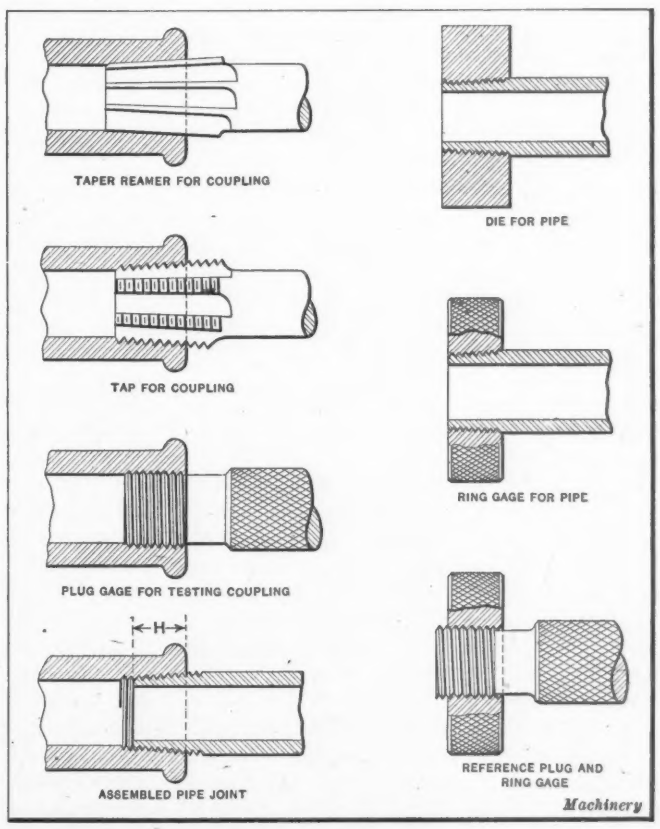
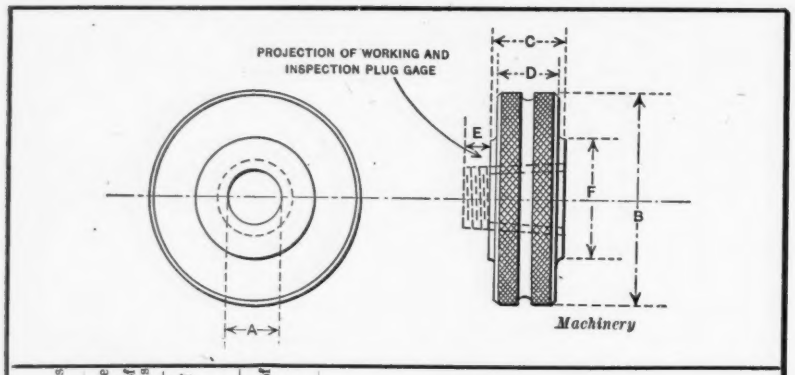



Fig. 6. Tools and Gages used in machining and gaging Pipe Fittings to Briggs Standards

TABLE VII. PROPORTIONS FOR BRIGGS STANDARD REFERENCE PIPE RING GAGES (CADILLAC MOTOR CAR CO.)




| Nominal Bore of Pipe, Inches | Approximate Outside Diameter of Pipe, Inches | Number of Threads per Inch | Diameter of Tap Drill, Inches | Dimensions in Inches | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | A | B | C | D | E | F |
| 1/8 | 13/32 | 27 | 21/64 | 0.340 | 1 5/16 | 0.264 | 13/64 | 0.1110 | 3/4 |
| 1/4 | 17/32 | 18 | 27/64 | 0.441 | 1 3/8 | 0.402 | 11/32 | 0.1805 | 7/8 |
| 3/8 | 11/16 | 18 | 9/16 | 0.576 | 1 7/16 | 0.406 | 11/32 | 0.1805 | 1 |
| 1/2 | 27/32 | 14 | 11/16 | 0.712 | 1 5/8 | 0.534 | 15/32 | 0.2500 | 1 1/8 |
| 3/4 | 1 1/16 | 14 | 29/32 | 0.922 | 1 7/8 | 0.546 | 31/64 | 0.2500 | 1 1/4 |
| 1 | 1 11/32 | 11 1/2 | 1 1/8 | 1.157 | 2 3/16 | 0.625 | 9/16 | 0.3040 | 1 3/4 |
| 1 1/4 | 1 11/16 | 11 1/2 | 1 15/32 | 1.500 | 2 13/16 | 0.719 | 21/32 | 0.3040 | 2 1/16 |
| 1 1/2 | 1 29/32 | 11 1/2 | 1 23/32 | 1.740 | 3 1/4 | 0.750 | 11/16 | 0.3040 | 2 1/2 |
| 2 | 2 3/8 | 11 1/2 | 2 3/16 | 2.213 | 3 11/16 | 0.757 | 11/16 | 0.3040 | 3 |

pitch diameter it is essential that the included angle be held to very close limits. The coarser the pitch of the thread, the smaller is the amount of error permissible in the included angle, and for this element the tolerances range from ± 0.10 degree for the coarser pitches to ± 0.25 degree for the finer pitches.

### Manufacturing Tolerances on Working and Inspection Thread Gages

As working and inspection thread gages must be hardened if satisfactory service is to be obtained from them, and as they wear much faster than reference gages, greater tolerances are permissible. As a general rule, the pitch is held to a tolerance of ± 0.001 inch per inch of length, and the pitch diameter is governed to a certain extent by the tolerance on the work. When the working and inspection gages are laid out in connection with the limit system of manufacture, the tolerances permitted on the "Go" and "Not Go" ends of the gage should be laid out with respect to the tolerances on the work. For instance, the maximum or "Not Go" end of the plug should be made larger than the maximum hole by an amount equal to the maximum manufacturing tolerance permissible on the gage, and the "Go" end should be made larger than the minimum tapped hole by an amount equal to the manufacturing tolerance permitted on the gage.

When the gage is new, of course, it will not enter the minimum tapped hole, but as a tap in most cases cuts larger than its actual size, the gage will enter holes slightly larger than those cut with a minimum tap. Another advantage of this practice lies in the fact that the greatest amount of wear is secured from the gage before it is worn too small. The manufacturing tolerances permitted on the pitch diameter of thread gages vary from + 0.0001 to + 0.00025 inch, depending on the size and pitch of the gage. For example, on a screw-thread plug gage for a ¼ by 20 screw, the tolerance on the pitch diameter of the "Go" end of the gage would be expressed 0.2180 + 0.0002 inch — 0.0000.

The tolerance on the included angle of the thread is generally held to practically the same limits as the reference gages. As any variations in the included angle of the thread directly affect the pitch diameter and as errors in lead also affect the pitch diameter, it is imperative that errors in the included angle of the thread be reduced to a minimum.

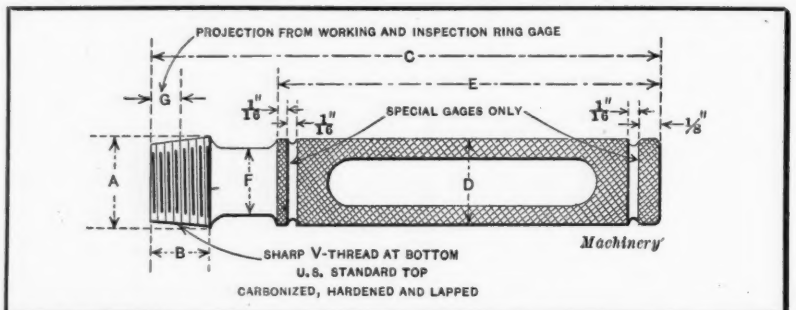
### Reference Thread Gages

Reference thread gages are made either from a good grade of tool steel and left soft or from machinery steel carburized and hardened. The soft gages, when carefully used, are more accurate than the hardened ones, owing to the elimination of warpage or distortion, which usually takes place during the carburizing and hardening process. Reference thread gages of comparatively coarse pitch can be ground with a diamond charged lap, and when this practice is followed the hardened reference gage is superior to the soft one. Ordinary lapping, however, cannot be depended upon to correct the lead of a distorted gage; for this reason reference thread gages are usually left soft.

A common form of reference thread gage consists of a plug and templet, as shown in Fig. 3. Here two forms of templets are shown, one of rectangular and the other of circular form. Both types are adjustable and are set to the master plug. In manufacturing plants where the limit system is employed, these types of reference thread gages are of little or no value because they cannot be used for setting the working or inspection gages, which are not set to a standard size but provide for tolerances on the work. In addition, as will be subsequently explained, a ring thread gage is of little value in testing the thread on a screw, as it is difficult to tell what element of the screw is in error.

In making reference screw gages for the U. S. standard form of thread, a flat of one-eighth the pitch is provided on the

TABLE VIII. PROPORTIONS FOR BRIGGS STANDARD REFERENCE PIPE PLUG GAGES (CADILLAC MOTOR CAR CO.)




| Nominal Bore of Pipe, Inches | Approximate Outside Diameter of Pipe, Inches | Number of Threads per Inch | Dimensions in Inches | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | A | B | C | D | E | F | G |
| 1/8 | 13/32 | 27 | 0.397 | 0.264 | 3 | 3/8 | 2 5/16 | 1/4 | 0.1110 |
| 1/4 | 17/32 | 18 | 0.528 | 0.402 | 3 1/4 | 7/16 | 2 7/16 | 3/8 | 0.1805 |
| 3/8 | 11/16 | 18 | 0.662 | 0.406 | 3 1/2 | 9/16 | 2 5/8 | 7/16 | 0.1805 |
| 1/2 | 27/32 | 14 | 0.822 | 0.534 | 3 3/4 | 5/8 | 2 5/8 | 9/16 | 0.2500 |
| 3/4 | 1 1/16 | 14 | 1.033 | 0.546 | 4 | 3/4 | 2 3/4 | 11/16 | 0.2500 |
| 1 | 1 11/32 | 11 1/2 | 1.290 | 0.625 | 4 1/4 | 7/8 | 2 7/8 | 13/16 | 0.3040 |
| 1 1/4 | 1 11/16 | 11 1/2 | 1.639 | 0.719 | 4 1/2 | 1 | 3 | 15/16 | 0.3040 |
| 1 1/2 | 1 29/32 | 11 1/2 | 1.881 | 0.750 | 4 1/2 | 1 | 2 7/8 | 15/16 | 0.3040 |
| 2 | 2 3/8 | 11 1/2 | 2.354 | 0.757 | 4 1/2 | 1 1/8 | 2 7/8 | 1 1/16 | 0.3040 |

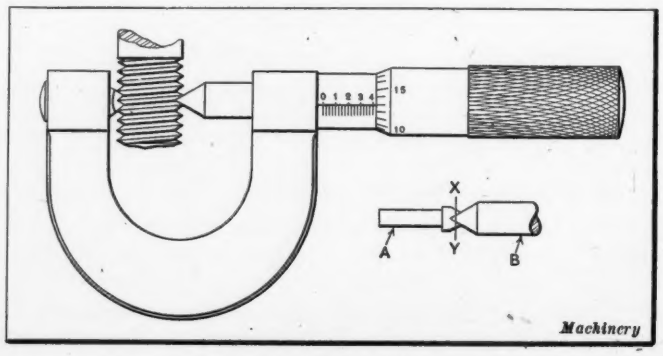



Fig. 7. Screw Thread Micrometer

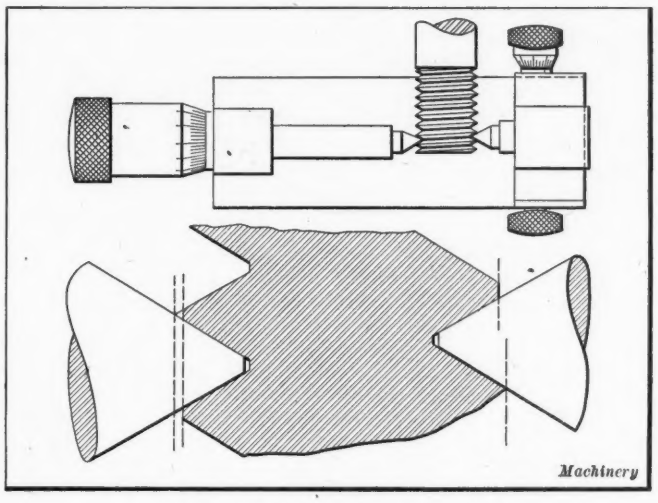



Fig. 8. Adjustable Thread Micrometer

outside diameter of the plug, whereas the bottom is made to a sharp V-shape in order to clear fine chips and dirt that may collect in the threads. The front end of the plug is also provided with three angular grooves to collect dirt and dust. The crest of the threads in the ring is made with a flat of one-eighth the pitch and the bottom is made to a sharp V as in the plug.

Fig. 5 shows a group of reference gages for British Whitworth standard threads. Ring *A* and plug *B* are left soft, and, of course, are used for reference purposes only. The form shown at *C* is provided with a threaded end and a plain cylindrical end having two shoulders, which represent the root and the outside diameter. *D* and *E* show two reference plugs that fill the same function as plug *C*.

Reference gages for use in connection with the limit system of manufacture should be made as shown in Fig. 24 in the October number of MACHINERY. This enables the inspection and working gages to be readily checked to determine when they are worn beyond the tolerances.

### Pipe-thread Reference Gages

There are two common forms of pipe-thread standards in use, *viz.*, the Briggs standard and the British standard, as shown at *A* and *B* in Fig. 4. The Briggs standard, however, is also made in a modified form, as shown at *C*, resembling the U. S. standard form of thread. The original Briggs standard pipe thread has an included angle of 60 degrees, and is slightly rounded at the top and bottom, so that the single depth of the thread, instead of being exactly equal to the pitch times 0.866 inch, is only four-fifths the pitch, or equal to the pitch times 0.8 inch. For the length of the pipe end throughout which the screw thread continues "perfect," the following formula is used:

$$(0.8\,D + 4.8) \times \frac{1}{n} \qquad (13)$$

in which $D$ = outside diameter of tube, in inches;

$n$ = number of threads per inch.

This distance is referred to as dimension $F$ in Fig. 4. Located back of the perfect threads is a section, including two threads, having a perfect bottom and a flat top; and still farther back is a portion having imperfect threads, which is formed by the chamfer or bell-mouth in the threading die. The perfect threads are cut on a taper equal to 3/4 inch to the foot, or 1/16 inch to the inch.

Fig. 6 shows the various tools necessary for machining and gaging a Briggs standard pipe joint. The joint should be tight when the pipe has entered the fitting a distance equal to $H$; but to allow for errors in manufacture, the thread on the pipe is cut two threads farther. The fitting should be tapped two threads deeper than as shown at $H$ for the same reason. For the value of $H$ for different sizes of pipe threads, see MACHINERY'S HANDBOOK. Tables VII and VIII, respectively, give proportional sizes for Briggs standard reference pipe ring and plug gages as used by the Cadillac Motor Car Co. These gages are made from a good grade of machine steel carburized and hardened, and are then lapped.

In the British standard form of pipe thread shown at *B* in Fig. 4, the thread form used is the standard Whitworth form having an included angle of 55 degrees, and the top and bottom are rounded similar to the standard form. The diameter of the screw is made to such size that the coupling or joint can be screwed on by hand to within four or five threads of the end of the threaded portion. The length of threads on standard pipe ends is found by the following formula:

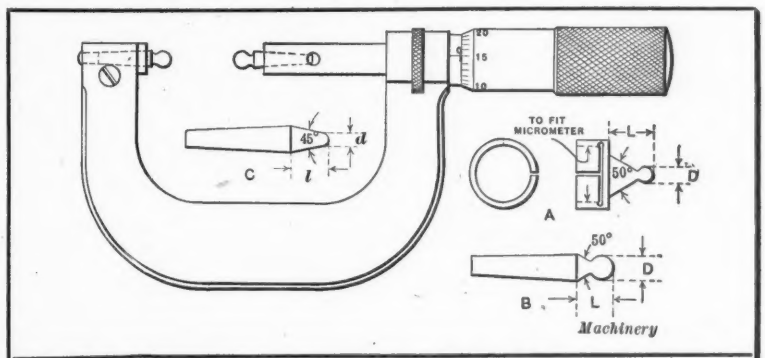
$$L = \sqrt[n]{D^2} - \tfrac{1}{8} \text{ inch} \qquad (14)$$

in which $L$ = length of thread, in inches;

$D$ = nominal bore of pipe, in inches.

The length of thread in the coupling or joint should not be made less than twice the length of thread on the pipe ends, and the length of thread at the end of a fitting must not be made less than the nominal length of thread on the corresponding end of the pipe.

TABLE IX. DIMENSIONS OF BALL POINTS USED IN MEASURING SCREW THREADS




| No. of Threads per Inch Calculated for | No. of Threads per Inch Used for | D, Inches | L, Inches | No. of Threads per Inch Calculated for | No. of Threads per Inch Used for | d, Inches | l, Inches |
|---|---|---|---|---|---|---|---|
| 3 1/2 | 3 1/2 | 0.164 | 9/32 | 18 | 18–20 | 0.031 | 3/32 |
| 4 | 4 | 0.143 | 9/32 | 22 | 22 | 0.026 | 1/16 |
| 4 1/2 | 4 1/2 | 0.127 | 9/32 | 24 | 24–26 | 0.023 | 1/16 |
| 5 | 5 | 0.111 | 9/32 | 28 | 27–30 | 0.020 | 1/16 |
| 6 | 6 | 0.095 | 5/32 | 32 | 32–34 | 0.018 | 1/16 |
| 7 | 7 | 0.081 | 5/32 | 36 | 36–38 | 0.016 | 1/16 |
| 8 | 8–9 | 0.070 | 5/32 | 40 | 40–46 | 0.014 | 1/16 |
| 10 | 10-11 | 0.059 | 3/32 | 52 | 48–60 | 0.011 | 1/16 |
| 12 | 12-13 | 0.049 | 3/32 | 66 | 62–72 | 0.0086 | 1/16 |
| 14 | 14–15 | 0.042 | 3/32 | .. | ..... | ..... | .... |
| 16 | 16 | 0.036 | 3/32 | .. | ..... | ..... | .... |

### Measuring Screw Threads with Micrometer Calipers

The simplest instrument and the one most commonly used for measuring screw threads where only a few are to be inspected is the micrometer caliper. In order to use the micrometer caliper for this work, and especially for measuring the pitch diameter and angle of thread, it is necessary either to provide the instrument with special measuring points or to make use of the common wire method.

### Screw Thread Micrometer

One of the many methods of measuring in the angle of the thread is by use of the thread micrometer shown in Fig. 7. The fixed anvil *A* is V-shaped, so as to fit over the thread, while the movable point *B* is cone pointed, so that it may enter the space between any two threads. The extreme end of the cone is removed so as not to contact with the bottom of the thread. The anvil is also provided with a clearance at the bottom of the V-groove so that both the anvil and the cone-pointed spindle will contact only with the sides of the thread. When the cone point and the anvil are in contact, the zero line on the thimble represents a line drawn through the plane X–Y. If the caliper

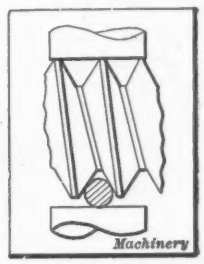



Fig. 9. Diagram illustrating One-wire System of measuring Threads

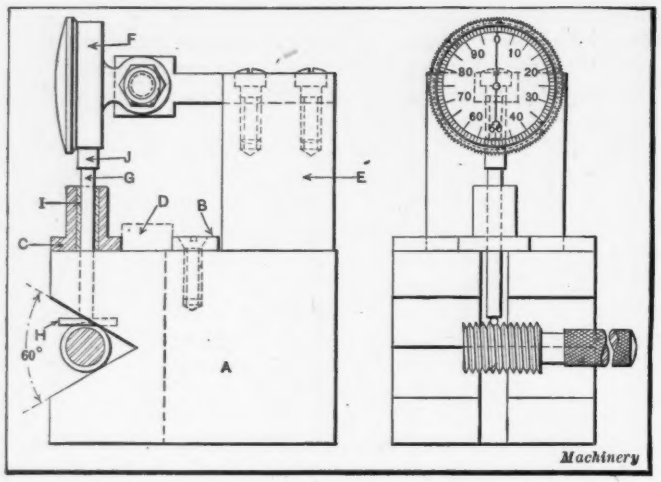



Fig. 10. Another Method of using One-wire System for Thread Measurement

is opened, say to 0.375 inch, it means that the two planes are 0.375 inch apart. The cone point is adapted for measuring all pitches, but the fixed anvil is limited in its capacity, and to cover all pitches it was necessary to provide different anvils for the various pitches.

To find the theoretical pitch diameter that is measured by this micrometer it is necessary to deduct the single depth for the thread from the outside diameter. Expressed in a formula for the various types of threads, the pitch diameter equals:

$$\text{For sharp V-thread,}^1\ D = d - \frac{0.866}{N} \qquad (15)$$

$$\text{For U. S. and A. S. M. E. standard threads, } D = d - \frac{0.6495}{N} \qquad (16)$$

$$\text{For Whitworth standard thread, } D = d - \frac{0.640}{N} \qquad (17)$$

in which $D$ = caliper reading or pitch diameter;
$d$ = nominal outside diameter of thread;
$N$ = number of threads per inch.

### Another Thread Micrometer

In the thread micrometer shown in Fig. 7, the offset of the center line of the anvil and cone-pointed spindle necessary to take care of the helix angle of the thread was provided for by holding the anvil so that it was free to rotate and by employing various anvils for different pitches of threads. In the micrometer shown in Fig. 8, the anvil is mounted in a slide and the amount of offset is controlled by a micrometer. To measure a thread of a certain pitch, the anvil is set off center an amount equal to one-half the pitch of the thread being measured.

[1] As it is not practicable to make a V-thread theoretically sharp, the outside will measure less than the nominal size, the pitch diameter remaining the same.

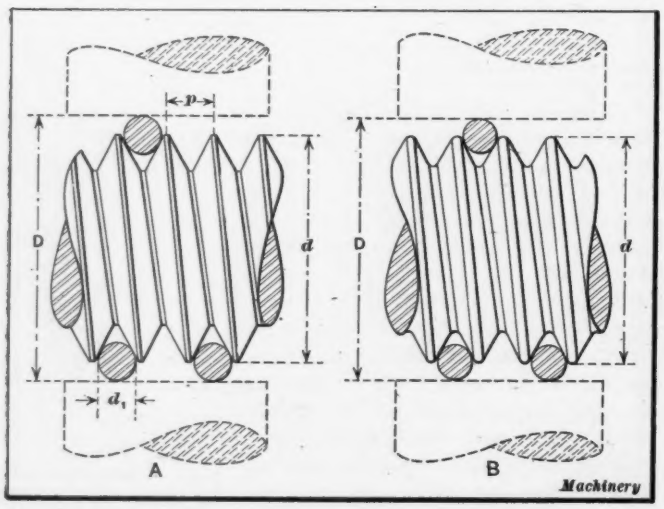



Fig. 11. Three-wire Method of measuring Screw Threads

### Measuring Screw Threads with a Micrometer Having Ball Points

The regular screw-thread micrometer has the disadvantage of being delicately constructed and of requiring careful and frequent adjustment. It is preferable to use the standard screw-thread micrometer for reference only and to measure screw plugs or screws by means of the standard micrometer fitted with different types of points.

There are many types of points used; the illustration accompanying Table IX shows three. The type shown at *A* is made to slip over both measuring points of the micrometer, and to get satisfactory results must be carefully made. However, these points, as a rule, do not fit solidly over the anvil and spindle of the micrometer even if they are split, and are apt to cause errors in measurement. Better types of points are shown at *B* and *C*. The ball point shown at *B* can be used for measuring threads as fine as 16 pitch. When a thread is finer than this, the neck becomes so small that there is not sufficient strength, and the point is formed as shown at *C*. This point can be used for measuring threads as fine as 72 threads per inch. By referring to Table IX, it will be noticed that the first column gives the number of threads for which the diameter of the point has been calculated, and the second column gives the other pitches for which this size of point can be used. These points will fit approximately half way between the top and root of the thread in the U. S. standard screw or threaded plug. Of course they are used for reference only, and are set by means of a standard screw plug. They do not check the angle of the thread, as does a regular screw-thread micrometer, but the angle can be obtained by using different sizes of points, and comparing the size near the root of the thread with one size of ball, using a larger ball for the pitch diameter, and a still larger one near the top. If these three measurements agree with the standard gage, the angle of thread is correct.

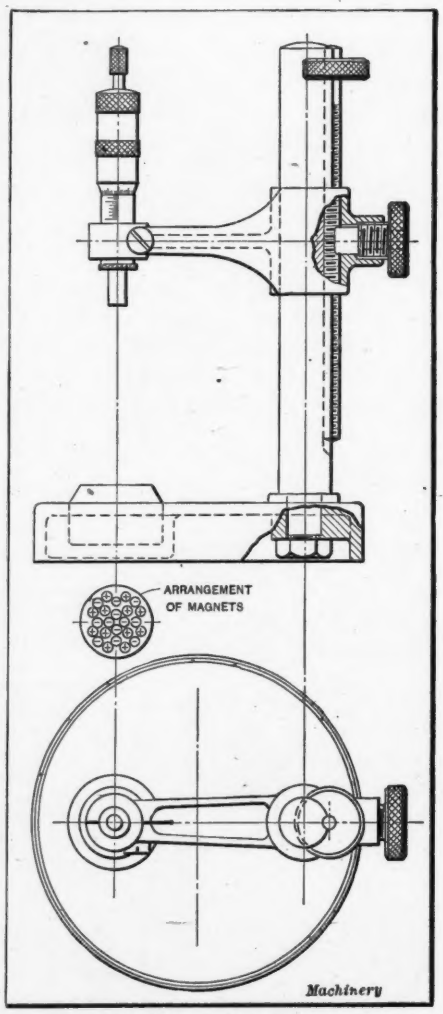



Fig. 12. Magnetized Stand for Use in measuring Threads by Three-wire Method

### One-wire System of Measuring Screw Threads

The pitch diameter of screw threads may be measured with an ordinary micrometer and one wire arranged as indicated in Fig. 9. If the outside diameter of the screw is large or small, allowance must be made for this in taking the measurement. If the screw is over size, one-half the amount that it is over size must be added to the dimensions obtained by the formulas. If it is under size, one-half the amount that it is under size must be deducted. One wire is easier to handle than three wires, but is not as generally used for other reasons, which will be given later. This method can also be used on coarse-pitch threads where the micrometer spindle will not

reach from one thread to the next, which is necessary with the three-wire system. Assuming that $D$ is the micrometer reading over the wire when the pitch diameter is correct, and T. P. I. represents threads per inch, the formulas for measuring with a micrometer and one wire are:

For sharp V-thread:

$$D = 1.5 \times \text{diameter of wire} - \frac{0.866}{\text{T. P. I.}} + \text{standard outside diameter} \quad (18)$$

For U. S. standard thread:

$$D = 1.5 \times \text{diameter of wire} - \frac{0.7577}{\text{T. P. I.}} + \text{standard outside diameter} \quad (19)$$

For standard Whitworth thread:

$$D = 1.583 \times \text{diameter of wire} - \frac{0.8004}{\text{T. P. I.}} + \text{standard outside diameter} \quad (20)$$

The size of wire is governed by the pitch and form of thread. The best size to use is about two-thirds the pitch. Mistakes can easily be made if too large a wire is used. A wire smaller than six-tenths or larger than nine-tenths the pitch should not be used.

### Thread Measuring Indicator Using One Wire

A thread measuring device for comparing screws with gages or working gages with master gages is shown in Fig. 10. This was designed to eliminate the personal element in measuring threaded parts or gages, as it has been found that in using thread micrometers, whether equipped with conical or ball points, measurements made by different men, or even by the same man, differ at times, and show variations as much as 0.0001 inch to 0.0003 inch. This tool has the objection mentioned in connection with Fig. 9 that the condition of the outside diameter of the thread is likely to affect the accuracy of the reading. It is based on two fundamental facts of trigonometry; one, that the axis of a cylinder held in an angular groove lies in the plane that bisects the angle, and that if

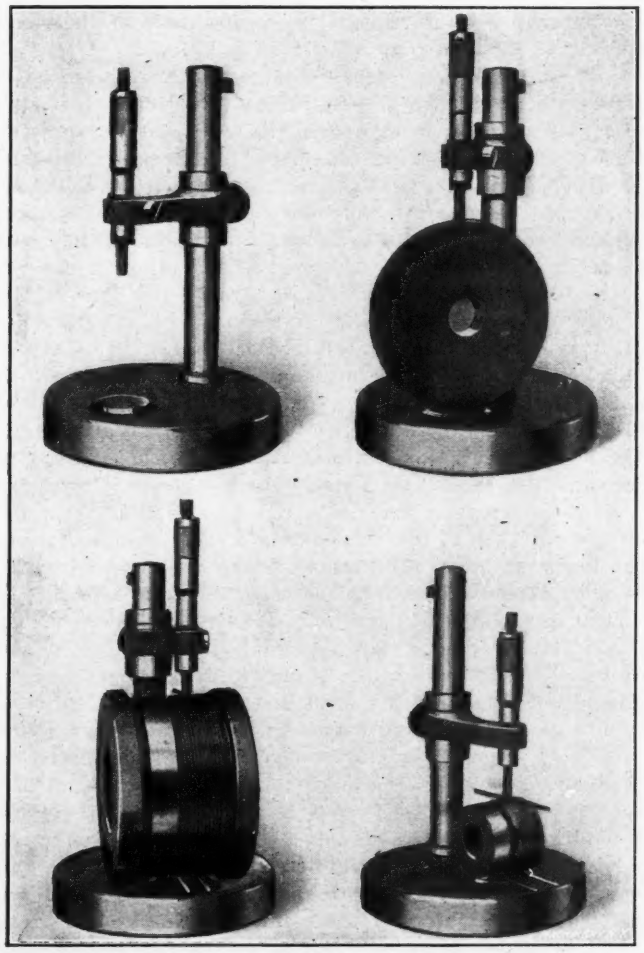


Fig. 13. Special Stand shown in Fig. 12 in Use measuring Reference Thread Gages

Fig. 14. Method of using Johansson Reference Blocks for measuring Screw Threads

the angle of the groove is 60 degrees, this axis will be at a distance from the vertex of the angle equal to the diameter of the cylinder.

Referring to Fig. 10, it will be noted that the tool consists of a block $A$ with a 60-degree groove in it and with a straightedge $B$ fastened to the top face by screws and dowels. The straightedge is so placed that the attachment $C$ can be adjusted to bring its axis to line up with the axis of the thread plug being measured, by inserting a standard measuring block $D$. On top of block $A$ is another block $E$ which carries the dial indicator reading to 0.0001 inch. Attachment $C$ carries rod $G$, which extends down through the slot cut in block $A$ and rests upon a wire $H$ laid between the threads of the work. To prevent wire $H$ from dropping out, rod $G$ is magnetized; and to prevent the magnetism from interfering with the free movement of rod $G$, the rod is surrounded by a brass bushing $I$, and is held from dropping out by a set-screw, not shown.

The wire $H$ is made of drill rod and is hardened and ground to exact size; an assortment of wires is provided for the different pitches of threads to be measured. A wire having a diameter equal to three-quarters or seven-eighths of the pitch works satisfactorily, but to facilitate calculation, it is well to keep an even number of thousandths, 0.120 for instance, instead of 0.125 inch.

If it is desired to compare a piece of threaded work with a standard, the standard is first clamped in the block $A$; then a size-block $D$, equal in thickness to the diameter of the standard, is inserted between attachment $C$ and straightedge $B$. Rod $G$ is then brought to bear on a wire laid in the threads of the standard, and the indicator spindle is brought over in contact with rod $G$ and a reading taken. The same process is repeated by removing the standard and inserting the piece to be measured; the difference between the two pieces will then be read off on the indicator in 0.0001 inch.

This device can also be used for originating measurements by replacing the dial indicator with a micrometer spindle, which carries an indicating needle, thus eliminating the necessity for "feel" on the part of the inspector. For originating measurements, however, the most satisfactory way is to use a standard measuring machine, as described in the October number of MACHINERY.

### Three-wire Method of Measuring Screw Threads

The three-wire method of measuring screw threads has the advantage over the one-wire method in that the outside diameter need not enter into the calculation in order to determine the pitch diameter. The three wires are arranged as shown at $A$ and $B$ in Fig. 11. One wire is placed in the angle of the thread on one side of the screw or threaded plug and the other two on the opposite side; the measurement is taken over the wires with a regular micrometer. The limit of this method is reached when the pitch of the thread is such that the micrometer anvil or spindle will not reach across the two wires. If the pitch diameter is correct, the micrometer readings for the various forms of threads are:

For sharp V-thread:

$$d = D - 3d_1 + 1.732p \quad (21)$$

$$D = d - 1.732p + 3d_1 \quad (22)$$

For U. S. and A. S. M. E. standard threads (*A*, Fig. 11):

$$d = D - 3d_1 + 1.5155p \quad (23)$$

$$D = d - 1.5155p + 3d_1 \quad (24)$$

For Whitworth standard thread (see *B*, Fig. 11):

$$d = D - 3.1657d_1 + 1.6008p \quad (25)$$

$$D = d - 1.6008p + 3.1657d_1 \quad (26)$$

For British Association standard thread:

$$d = D - 3.4829d_1 + 1.81814p \quad (27)$$

$$D = d - 1.81814p + 3.4829d_1 \quad (28)$$

For German Lowenherz thread:

$$d = D - 3.2368d_1 + 1.75p \quad (29)$$

$$D = d - 1.75p + 3.2368d_1 \quad (30)$$

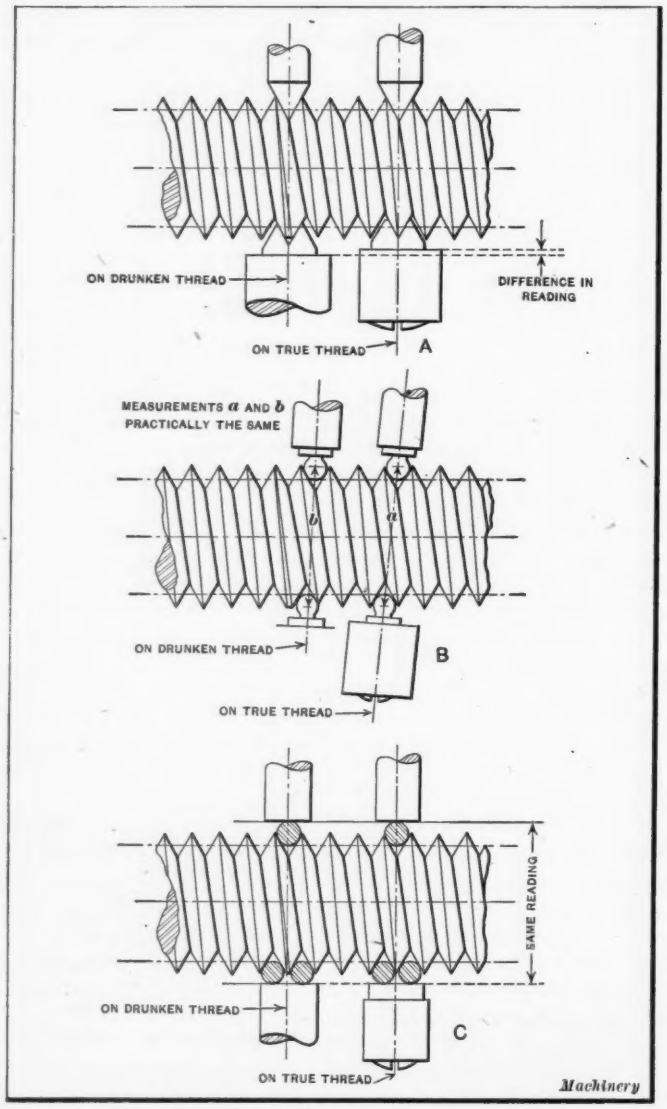



Fig. 15. Diagram illustrating Failure of Ball Point and Three-wire Method of Measurement to detect Drunken Threads

in which $D$ = micrometer reading over wires;
$d$ = standard outside diameter of screw;
$d_1$ = diameter of wires;
$p$ = pitch.

Taking the U. S. standard thread formula as an example, assume that the standard outside diameter $d$ is 0.5 inch. The number of threads per inch is 13; hence, the pitch is 0.0769. The diameter $d_1$ of the wires used is 0.050 inch. Then:

$$D = 0.500 - (1.5155 \times 0.0769) + 3 \times 0.050$$
$$= 0.500 - 0.1166 + 0.150 = 0.3834 + 0.150$$
$$= 0.5334 \text{ inch.}$$

### Methods of Using Three-wire System

Difficulty is sometimes encountered in applying the three-wire system owing to the necessity for retaining all three wires accurately in the grooves of the thread. One method of overcoming this objection consists in the use of a special stand, as shown in Fig. 12. This stand consists of a cast-iron base carrying a column to which is clamped a micrometer head that is adjusted by a vertical screw. Directly beneath the micrometer head and embedded in the base, is a gun-metal bushing holder in which is placed a series of magnetized cylindrical pins arranged as shown in the plan view. These pins prevent the wires on the anvil from rolling off and also enable them to be accurately placed. The magnets are arranged with their negative and positive poles as indicated. In applying the instrument the micrometer is adjusted until it registers the exact size of the cylindrical reference gage, as shown in Fig. 13. Then the dimensions measured over the wires can be read off directly from the micrometer, care being taken to see that the temperature of the reference gage and the gage being tested are the same.

Another simple but satisfactory method of applying the three-wire system is shown in Fig. 14. In this case use is made of the Johansson standard holder and the regular thickness blocks. The holder retains two carefully ground and lapped blocks, which are spaced the required distance apart by using the regular Johansson thickness blocks. Against the face of one block two wires of the required size are placed and the plug to be measured is then brought up against these. A third wire is used to test the accuracy of the work by being tried in the grooves on the opposite side. This makes a very sensitive test, as there is no pressure to consider except the weight of the small wire, which is almost negligible. It is therefore possible for the inspector to detect the slightest error. The limit of tolerance on this gage is 0.0002 inch.

### Comparison of Ball Point and Anvil Type of Thread Micrometer

Several forms of measuring points are employed for comparing the pitch diameters of threaded work. That used in the Brown & Sharpe thread micrometer is shown at *A* in Fig. 15. This may be used for positive measurements as well as for comparison. At *B* and *C* are illustrated other principles of measuring, the former using a ball-point micrometer, and the latter three wires of suitable diameter, measured with the regular micrometer caliper. The arrangements shown at *A* and *C* may be used either for positive measurements or comparison with other threads. The device shown at *B*, however, owing to the tilting of the micrometer, should be used only for comparative measurements between threads of the same form.

A recent experiment proved that the method shown at *B* can only be relied upon in certain cases, even for comparative measurements, and the same holds true of that shown at *C*. The way in which this was discovered brings up an interesting point in machine-tool construction as well as in thread measuring. A manufacturer bought a lathe for cutting accurate threads, which was provided with an accurate lead-screw. A serious error, however, developed in mounting in the machine. It was provided with a loose thrust collar between the shoulder of the lead-screw and the face of the bearing bracket which took the thrust in feeding the carriage. This thrust collar was poorly squared up, being some thousandths inch thicker on one side than on the other. Unfortunately, the thrust surfaces on the lead-screw in the bearing between which it was placed were also poorly faced, running out sideways to an appreciable extent. As a result, the lead-screw in revolving received an irregular endwise movement resulting from the varying positions of the untrue loose washer between its untrue thrust surfaces. The machine thus cut an irregular, or drunken, thread. This fact was brought to the attention of the makers of the machine, who measured the lead-screw with a ball-point micrometer, also a sample screw cut by it, and pronounced it O. K. The purchaser of the machine, however, brought out a measuring tool of the type shown at *A*, which at once indicated varying diameters in different parts of the threads on the work, giving evidence of the irregularity of which he complained. The reasons for this were evident. The ball-point micrometer shown at *B* measured the groove cut by the thread tool; and as this is always set at the same depth and is unvarying in shape, the error was not detected. The same conditions are met with the three-wire method shown at *C*. The lower anvil of the point at *A*, however, since it spans the abnormal thread, instead of making contact with the side of the adjacent threads, indicates the irregularity by giving an increased reading for the pitch diameter.

# HOW AND WHY

QUESTIONS ON PRACTICAL SUBJECTS OF GENERAL INTEREST

## CENTRIFUGAL FORCE—A CORRECTION

A. H.—I read with great interest the answer on centrifugal force on page 63 of MACHINERY for September. I cannot, however, follow the geometry of the proof. In Fig. 1, angle $NMN_1$ is always equal to one-half $MON$, no matter how small the latter may be. Will you please explain a little more fully?

A.—The writer intended to have drawn the line $MN$ tangent to the circle at $N$, in which case, the angle $NMN_1$ would have been exactly equal to $MON$. Note that the lines $MN_1$ and $N_1N$ in Fig. 2 represent velocities, not distances, and their lengths are not therefore comparable with the lengths of lines having the same letters in Fig. 1. J. J.

## ORIGIN OF INSERTED-BLADE REAMERS

W. F.—I would like to know who was the inventor of the reamer with inserted blades.

A.—The name of the inventor of the inserted-blade reamer is not known. Inserted-blade reamers and inserted-cutter lathe tools were used in the Portsmouth Navy Yard shops of the British government as early as 1830, according to a statement appearing in a book, "Turning and Mechanical Manipulation," by Charles Holtzpffal, a work published in 1843. The particular type of inserted-blade reamer shown in Holtzpffal's book had four blades of approximately square section, set 90 degrees apart. The blades were fitted snugly in longitudinal grooves, and apparently no clamping device was provided or required.

## SHORT RULE FOR CALCULATING WEIGHT OF WATER

H. M. L.—Please give an easy, accurate rule for calculating the weight of water, the volume being given in cubic inches.

A.—The weight of water varies considerably with the temperature; also, any impurities held in solution will affect its weight. In practice, it is sufficiently accurate to take the weight of a cubic foot as 62.4 pounds. In this case, 1 cubic inch weighs $\frac{62.4}{1728} = \frac{13}{360}$ pound $= \frac{12}{360} + \frac{1}{360} = \frac{1}{30} + \frac{1}{30} \times \frac{1}{12}$ pound. Hence, divide the number of cubic inches by 30; divide the quotient by 12; then add the two quotients. For example, what is the weight of a gallon of water? One gallon contains 231 cubic inches; $231 \div 30 = 7.7$; $7.7 \div 12 = 0.64\ 1/6$; $7.7 + 0.64\ 1/6 = 8.34\ 1/6$ pounds. Note that the fraction 13/360 is convenient for use on the slide-rule. J. J.

## CENTER OF GRAVITY OF ARC AND SEGMENT OF CIRCLE

W. J. B.—On page 266 of MACHINERY'S HANDBOOK, a formula is given for finding the center of gravity of an arc of a circle, which reduces to $a = 0.6366r$ for a semicircle. On page 267, a formula is given for finding the center of gravity of a circular segment, which for a semicircle reduces to $a = 0.4244r$. This latter constant is just two-thirds that of the former; should they not be alike, or have I made some mistake in reducing?

A.—Both constants are correct; in the first case, we are dealing with a line, and in the second case, with an area. Both formulas may be verified experimentally as follows: Take a piece of very fine, stiff wire and bend it into the form of a semicircle; then balance it on a knife-edge in such a way that the two ends will be parallel to the line formed by the knife-edge. The distance from a line through the two ends and the knife-edge should be equal to the distance $a$, as determined by the formula on page 266. The other case may also be verified in a similar way by using a flat plate of uniform thickness and material. J. J.

## STRENGTH OF COLD-ROLLED SHAFTING

H. B. H.—I wish to obtain some data on the strength of cold-rolled shafting when the outer shell of refined metal produced by the cold-rolling process has been removed.

A.—Comparatively little data on the strength of cold-rolled and cold-drawn shafting having the outer shell of metal removed are available. Obviously, the refining effect of the cold-rolling or drawing process cannot penetrate deeply, and it is fair to assume that the core would not have physical characteristics much different from those of the same grade of steel, hot-rolled. The cold-rolling and cold-drawing processes refine and strengthen the outer shell of metal the same as wire is refined and strengthened by being drawn. This outer shell has a tensile strength of perhaps one and one-half or two times that of the core, and being on the outside, it increases the bending strength of the shaft out of all proportion to the amount of the drawn and refined metal.

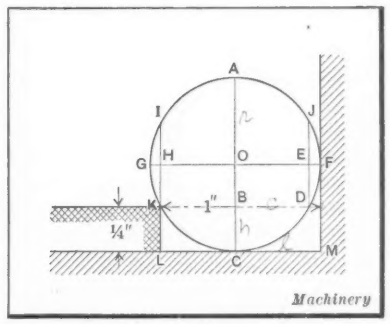
## ADDITION AND SUBTRACTION WITH LOGARITHMS

G. T. V.—I claim that addition and subtraction cannot be performed with logarithms, but a friend tells me I am wrong; which of us is right?

A.—Ordinary logarithms cannot be used for addition and subtraction, but tables of what are called Gaussian logarithms have been constructed for this purpose; they depend on the following principle: $\log (a + b) = \log a \left(\frac{b}{a} + 1\right) = \log a + \log \left(\frac{b}{a} + 1\right)$; and $\log (a - b) = \log b \left(\frac{a}{b} - 1\right) = \log b + \log \left(\frac{a}{b} - 1\right)$. In these expressions, $a$ is always supposed to be greater than $b$. The table gives the logarithms of the fractions as arguments and the logarithms of the quantities in parentheses as functions, the interpolation being performed exactly as in the case of ordinary logarithms. These tables are very useful in connection with certain calculations, but they do not seem to be much used in this country. J. J.

## PROBLEM IN MENSURATION

J. W.—Referring to the illustration, please show how to find the diameter of the circle from the dimensions given. I should like a formula that will solve any similar case.



Problem in Mensuration

A.—Draw the horizontal and vertical diameters $GF$ and $AC$; also draw the chord $KD$ parallel to $GF$, and through $K$ and $D$, draw chords $KI$ and $DJ$ parallel to $AC$. $AC$ bisects $KD$ in $B$, and $GF$ bisects $IK$ in $H$ and $JD$ in $E$. Let $BD = c$, $CB = h$, $LM = l$, and $OA = r$; then, $c^2 = AB \times BC = (2r - h)\,h = 2rh - h^2$; or $c = \sqrt{2rh - h^2}$. Also, $LM = EH + EF = c + r = \sqrt{2rh - h^2} + r = l$. Transposing $r$ to the right-hand member and squaring both sides, $2rh - h^2 = l^2 - 2rl + r^2$. Transposing and collecting terms, $r^2 - 2(l + h)r + l^2 + h^2 = 0$. This last is an affected quadratic equation, which may be solved by the usual rule, and gives $r = l + h \pm \sqrt{2lh}$. Substituting the given values for $l$ and $h$, $r = 1 + \frac{1}{4} \pm \sqrt{2 \times 1 \times \frac{1}{4}} = 1\frac{1}{4} \pm \frac{1}{2}\sqrt{2} = 1.95711$, or $0.54289 +$. The smaller value is evidently the one desired in this case; hence, $d$ = the diameter sought $= 2 \times 0.54289 = 1.08578 —$ inch. J. J.

## FIXING SHAFT, BEARING AND PULLEY BORE DIMENSIONS

L. C.—Owing to differences of opinion of three mechanics, a matter was brought to my attention which I wish to submit as follows: A ⅞-inch cold-rolled steel shaft running at 1500 R. P. M. is fitted in cast-iron bearings, and has mounted upon it a solid hub cast-iron pulley, secured by two set-screws. A suggests that the dimensions be fixed thus:

Shaft ⅞ inch = 0.875 inch;
Bearings ⅞ inch + 0.005 inch = 0.880 inch;
Pulley ⅞ inch + 0.002 inch = 0.877 inch.

B suggests the following instead:

Shaft ⅞ inch — 0.002 inch = 0.873 inch;
Bearings ⅞ inch + 0.003 inch = 0.878 inch;
Pulley (reamed) ⅞ inch = 0.875 inch.

C would give the bearings the standard dimensions:

Shaft ⅞ inch — 0.005 inch = 0.870 inch;
Bearings ⅞ inch = 0.875 inch;
Pulley ⅞ inch — 0.003 inch = 0.872 inch.

It was agreed by all that an allowance of 0.005 inch should be permitted between the shaft and bearing and an allowance of 0.002 inch between the shaft and pulley, but no agreement could be reached as to which should have the basic diameter of ⅞ inch.

A.—There is no absolute fixed rule governing this case. Common practice in the past has been to make the pulley hub hole the standard or nominal size and the shaft to fit, but there has been a change in late years, due to the more general use of cold-drawn shafting. The tendency now is to make the shaft the fixed or nominal size and bore the pulley and bearings to fit. The suggestion of A agrees with this practice.

## DEPTH OF FLOTATION

W. J. B.—A cylindrical tank that is 7 feet in diameter and 30 feet long is sunk in water to within 1 foot of the top; what is the pressure tending to raise the tank? The weight of the tank is 4 tons.

A.—The pressure tending to raise a body that is submerged or partly submerged is always equal to the weight of the liquid displaced. Assuming that the axis of the tank is horizontal, the volume of water displaced is the same as that of a solid having a base $ACB$ and an altitude of 30 feet, the length of the tank. First calculate the area of the segment $ADB$ and subtract this from the area of the circle $ACBD$; the remainder will be the area of the segment $ACB$. The radius $OA = 7 \div 2 = 3.5$ feet; the height of the segment is $ED = 1$ foot; hence, $OE = 3.5 - 1 = 2.5$ feet, and $\cos AOD = 2.5 \div 3.5 = 0.7142857$. The angle corresponding to this cosine is 44 deg., 24 min., 55 sec., and $AOB = 88$ deg., 49 min., 50 sec. = 1.5503857 radian. The area of the segment $ADB$ is $\frac{1}{2} r^2(V - \sin V) = \frac{1}{2} r^2(1.5503857 - 0.9997917) = 3.3724$ square feet, $V$ being the central angle $AOB$. Area of $ACB = \pi \times 3.5^2 - 3.3724 = 35.1122$ square feet. Taking the weight of a cubic foot of water as 62.5 pounds, the weight of the water displaced is $35.1122 \times 30 \times 62.5 = 65{,}835$ pounds, say 33 tons. As the tank weighs only 4 tons, an additional weight of $33 - 4 = 29$ tons must be placed on the tank in order to sink it to the required depth. J. J.

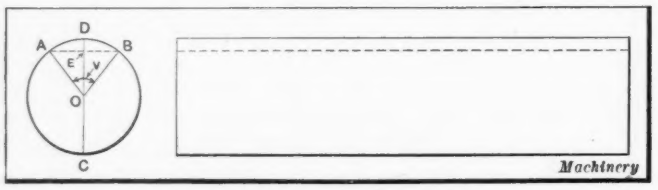
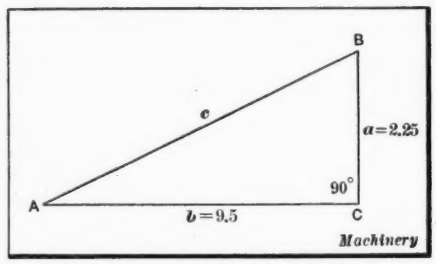



Diagram illustrating Depth of Flotation

## ACCURACY IN CALCULATION

F. E. K.—In a right triangle, one of the legs is 2.25 inches and the other is 9.5 inches. I calculated the hypotenuse in three different ways and got three different results; thus: $\tan A = 2.25 \div 9.5 = 0.23684 = \tan 13$ deg., 19 min.; $c = a \div \sin A = 2.25 \div \sin$ 13 deg., 19 min. $= 2.25 \div 0.23033 = 9.76859$. $c = b \div \cos A = 9.5 \div 0.97311 = 9.76251$. $c = \sqrt{2.25^2 + 9.5^2} = 9.76281$. I obtained the sine, cosine, and tangent from MACHINERY'S Reference Book No. 55; if this is correct, why don't I get the same answer each time?

A.—There are a number of reasons why the first two results do not agree with the third. In the first place, a table of trigonometric functions will give only as many significant figures correct in the final result as there are significant figures in the functions, and frequently the last figure may be one or even two units too large or too small. As the table used gives the functions correct to five significant figures, you cannot expect to get the hypotenuse correct to more than five significant figures; *i. e.*, if you obtained for a result 9.7628, the result may be considered correct. In the second place, you have expressed the angle only to minutes and have neglected the seconds; the angle the tangent of which is 0.23684 is 13 deg., 19 min., 28 sec., and the sine of this angle is 0.230465, these values being as close as can be obtained with a five-place table. Using this value for the sine, $c = 2.25 \div 0.230465 = 9.76287$, or 9.7629 to five figures. Observe that this is one unit too large in the last place. Using a seven-place table, and calculating the tangent to seven figures also, $\tan A = 0.2368421$, from which $A = 13$ deg., 19 min., 28.311 sec.; the sine of this angle is 0.2304664; whence, $c = 2.25 \div 0.2304664 = 9.762811$, which agrees with your third result to six significant figures. The seventh figure, however, should be 2 instead of 1. J. J.




Triangle, One Side of which is being found

## LAYING OUT A KITE-SHAPED TRACK

J. G. J.—We wish to lay out a kite-shaped race track; the circular part is to be one-half mile in length, and the two straight parts are to be one-quarter mile each; what should be the length of the radius?

A.—Referring to the illustration, $BA = BC = \frac{1}{4}$ mile; arc $AD$ = arc $DC = \frac{1}{4}$ mile; $A$ is the point of tangency, and $OA$ is the radius sought. Since $OA$ is perpendicular to $AB$, angle $AOD = \frac{\pi}{2} + \phi$. $\tan \phi = r \div \frac{1}{4} = 4r$; arc $AD = \left(\frac{\pi}{2} + \phi\right) r = \frac{1}{4}$. From these two equations, $r = OA = \frac{\tan \phi}{4} = \frac{1}{2\pi + 4\phi}$, or $\tan \phi = \frac{4}{2\pi + 4\phi}$. To find an approximate value of $\phi$, substitute for $\tan \phi$ the first two terms of the tangent series, obtaining $\tan \phi = \phi + \frac{\phi^3}{3} = \frac{4}{2\pi + 4\phi}$. Clearing of fractions, the equation becomes $4\phi^4 + 2\pi\phi^3 + 12\phi^2 + 6\pi\phi - 12 = 0$. Solving this equation by Horner's method, $\phi = 0.4605$ radian = 26.4 degrees, nearly. This value is probably a little large, as only two terms of the tangent series were used; if a closer value is desired, a table may be constructed as follows:

| $\phi$ Deg. | Min. | $\frac{\tan \phi}{4}$ | $\frac{1}{2\pi + 4\phi}$ | |
|---|---|---|---|---|
| 26 | 10 | 0.1228346 | — 0.1233051 | = — 0.0004705 |
| 26 | 15 | 0.1232863 | — 0.1232167 | = + 0.0000696 |
| 26 | 20 | 0.1237387 | — 0.1231285 | = + 0.0006102 |

The values in the second and third columns are approximate values of $r$, and are found by substituting in the forms at the head of the columns the value corresponding to $\phi$ in the first column. Inspection of the table shows that the difference becomes zero somewhere between $\phi = 26$ degrees, 10 minutes, and $\phi = 26$ degrees, 15 minutes; by interpolation, $\phi$ is found to be 26 degrees, 14.35545 minutes = 26 degrees, 14 minutes, 21.33 seconds. Substituting this value in either of the expressions for $r$, $r = 0.1232281$ mile = 650.6442 feet. It may be remarked that problems of a

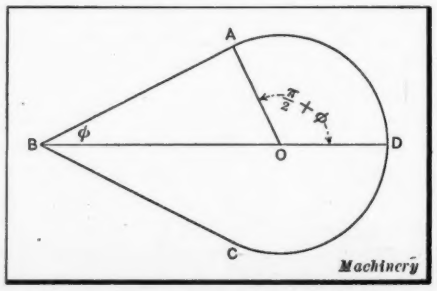



Diagram for laying out Kite-shaped Track

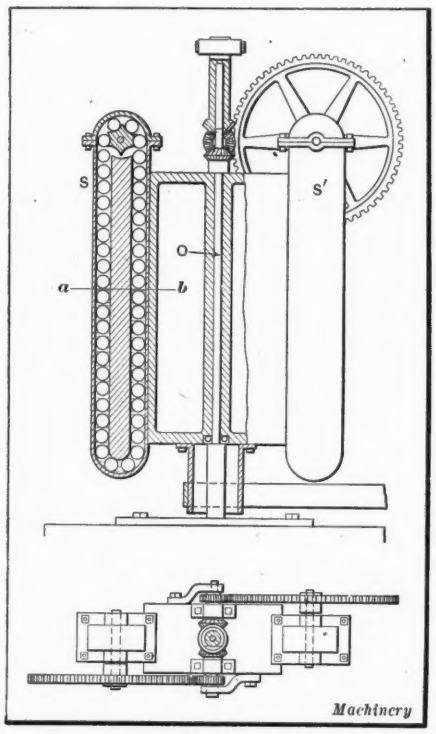



Fig. 1. Part Sectional and Top Views of Perpetual Motion Machine

nature similar to this frequently arise in practice; the calculation is exceedingly laborious, and the method just explained is the only one known to the writer by which all such problems may be successfully attacked. J. J.

## PERPETUAL MOTION MACHINE

J. E. B.—I send you herewith a circular describing a perpetual motion machine. Will you please explain why this machine will not work?

A.—Referring to the illustrations, Fig. 1 represents a half sectional view and a top view of the machine. From a very meager description, we understand that the machine is supposed to work as follows: The casings *S* and *S'* are filled with two columns of balls, the balls touching one another and the tubes containing them having a square cross-section. The casings are half full of mercury, say to the line *ab*. The whole apparatus is to be set spinning about the spindle *O*, with the result that the centrifugal force will cause the mercury in the outer column of the casings to rise higher than in the inner column. Since the balls are lighter than the mercury, those in the outer column will rise (and those in the inner column will fall) with the mercury; this will cause the various gears to turn and keep up the motion indefinitely. Suppose the vessel *V*, Fig. 2, is partly filled with a liquid, and is rotated about the axis Y'–Y through the center of the cross-section of the vessel. The surface of the liquid will no longer be flat, but curved, and a vertical section through its center, as *ACB*, will be a parabola, the surface being a paraboloid of revolution. The depth *DC* will depend entirely on the speed, in revolutions per minute, and for some particular speed, it will be *DC*, and the curve will be as shown in Fig. 2. If, now, another vessel *V'*, say a tube, is partly filled with a liquid and rotated about the axis Y'–Y, and with the same speed, the surface *mn* will be a part of the same paraboloid *ACB*. Here *V'* corresponds to one of the casings in Fig. 1. It should be noted, however, that for any particular speed, the surface has its own special shape, and it will not be altered as long as the speed is not changed; if it decreases, the points *C* and *n* rise, while *A* and *m* fall, and *vice versa*. Referring again to Fig. 2, let *P* be the position of a particle of the liquid; the centrifugal force may be represented by the horizontal line *PF* and the weight by the vertical line *PG*; completing the parallelogram, the diagonal *PN* is the resultant, and, according to Pascal's law, must be perpendicular to the surface of the liquid. Since the centrifugal force changes with the speed and the weight of the particle does not change, the position of the point *P* is determined by the speed only. In Fig. 1, the mercury in the outer tube will rise higher than in the inner tube, but whether this will cause the balls in the outer tube to rise also will depend on the amount of friction in the gearing, the mercury, etc. Even if they did move, the system would immediately put itself in static equilibrium, and the friction would cause the rotative speed to decrease. The machine cannot start itself, and it cannot increase its speed of rotation, nor even keep it up, after it has once been started. J. J.

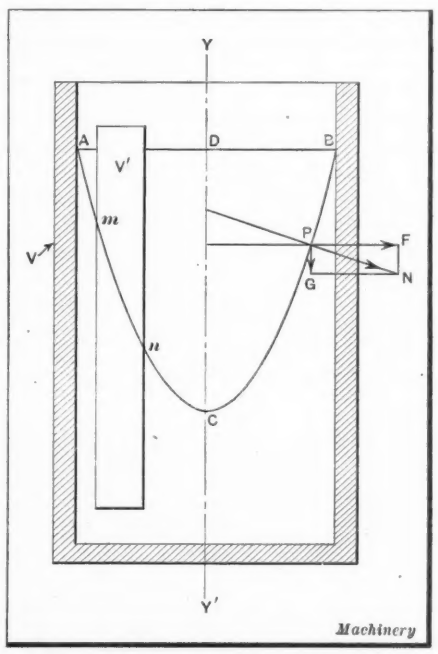



Fig. 2. Cross-section of a Vessel, showing Form assumed by Surface of Liquid when Vessel is rotated

## UNIT OF ENERGY

R. S. P.—In a recent article in a technical journal, I notice that the kinetic energy of a shell is given as a certain number of foot-tons; should it not have been foot-tons per second? If not, what becomes of the time element in the velocity?

A.—The unit of energy is always the same as the unit of work; it is the unit of power that contains the time element. The time element in the velocity is cancelled by the time element in the acceleration, as will be readily seen if, instead of taking the unit of time as one second, we take it as $t$ seconds. The formula, kinetic energy $= \frac{1}{2}mv^2 = \frac{wv^2}{2g}$, then becomes $\frac{w\left(\frac{v}{t}\right)^2}{2\frac{g}{t^2}} = \frac{wv^2}{2g}$. In this last expression, the unit of time is one second, as before. Or, since $\frac{v^2}{2g} = h$, $\frac{wv^2}{2g} = w\left(\frac{v^2}{2g}\right) = wh$; here $h$ is the distance that a body would fall in attaining the velocity $v$. If $h$ is expressed in feet and $w$ in tons, the product is foot-tons, and the unit of time is not involved. J. J.

## PRESSURE ON A SCALE BAR

R. J. T.—I enclose a sketch showing a scale bar. Desiring a formula for finding the pressure at $W$ for any position of the scale block $w$, I derived the following, and wish to know if it is correct: $WL = wl + w_1l_1$, $l = \frac{w_1l_1 - WL}{w}$. Also, do you know of any literature containing formulas of this nature?

A.—The formula is not correct, for the reason that you have made a mistake in finding the value of $l$; it should be $l = \frac{WL - w_1l_1}{w}$. Furthermore, if you wish exact results, you must take into account the weight and center of gravity of that part of the bar that extends to the right of the pin, which should preferably be a knife-edge instead of a pin. Calling this weight $w_2$, and the distance from the center of the pin to the center of gravity $l_2$, $WL + w_2l_2 = wl + w_1l_1$, or $l = \frac{WL + w_2l_2 - w_1l_1}{w}$. Problems of this kind are treated in mechanics under the head of moments and couples; any good elementary work treating on statics should give you the information. "Mechanics for Beginners," by J. B. Lock, is a good book, but is rather difficult for a beginner. J. J.

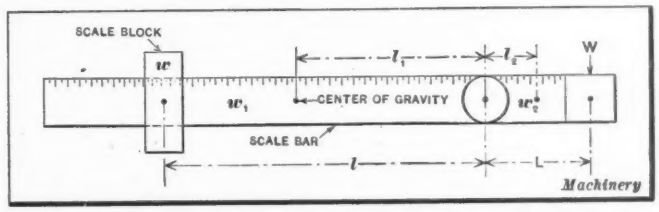
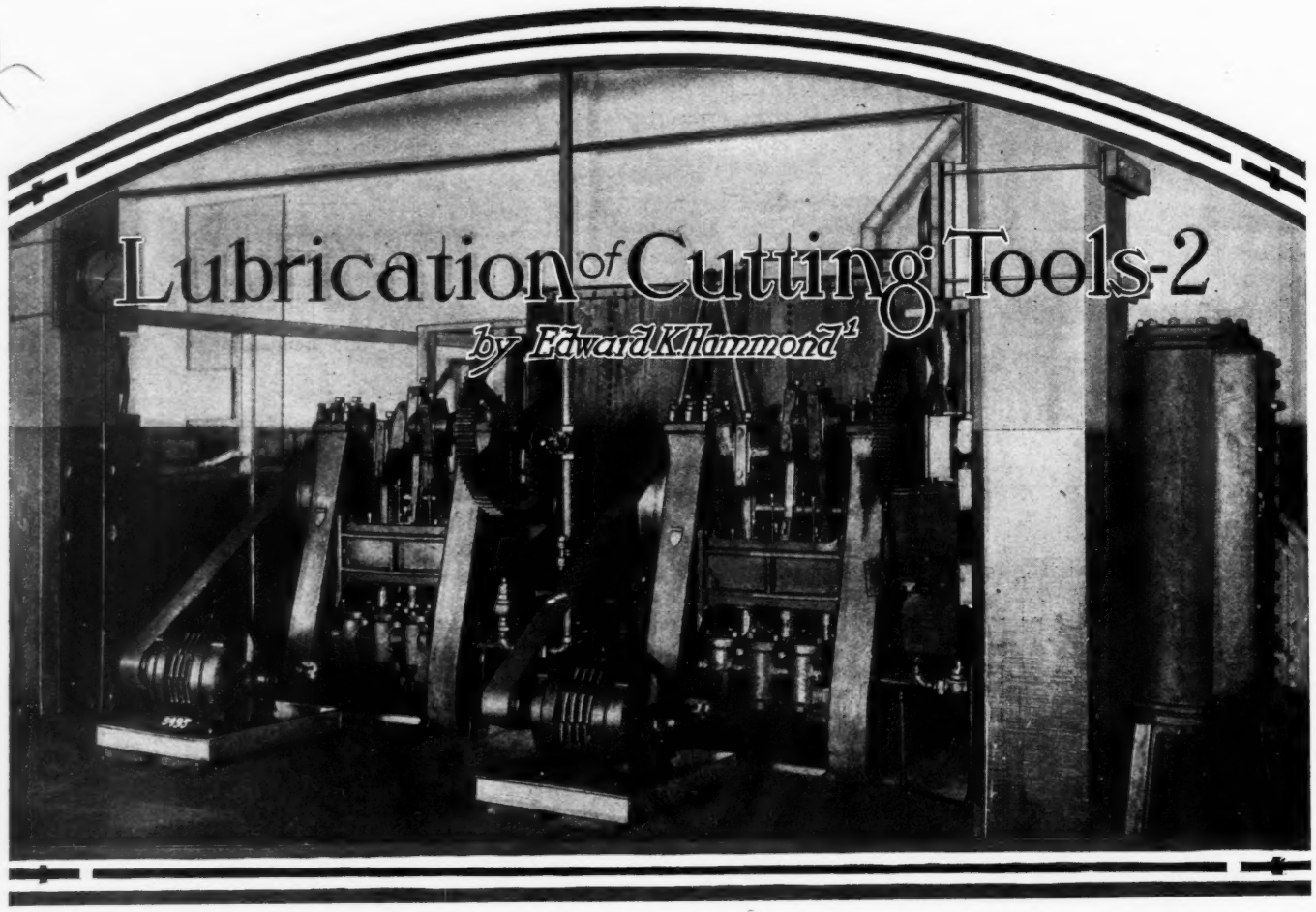



Diagram illustrating Pressure on Scale Bar



# Lubrication of Cutting Tools-2

by Edward K. Hammond[1]

AFTER spending much time and care in developing equipment and an organization to secure efficient production, many manufacturers are losing much of the benefit of this work through the use of unsuitable oils or cutting compounds. It is known that the purity of an oil or compound delivered to metal-cutting tools is a most important factor in determining the amount and quality of service that will be obtained from the tools. When great care is not taken, in filtering, to remove such impurities as oxide or scale and particles of metal from the oil, the fluid frequently becomes heavily charged with these impurities and trouble is experienced through rapid wear of bearings and slides of machine tools, rapid destruction of the cutting edge of tools, and inferior finish on the work. The following analysis of cutting costs shows what an important effect the purity of oil or cutting compound may have on the cost of production.

### Analysis of Cutting Cost

Cutting costs can be classified under the following heads:

Labor: (1) Operation of machine tools; (2) time occupied in changing dull tools; (3) time occupied in resharpening tools.

Power required to drive machines.

Cost of steel for cutting tools.

The cost of labor for operating machine tools will naturally vary according to the location of the factory and the skill required for conducting the various machining operations. This labor cost per unit of work produced is naturally cut down by any increase effected in the rate of production, and one important way of obtaining higher production is to increase the life of cutting tools so that delays occasioned by shutting down machines for changing tools is reduced as far as possible. The use of good cutting lubricants may be responsible for an increase in production of as much as 35 or 40 per cent.

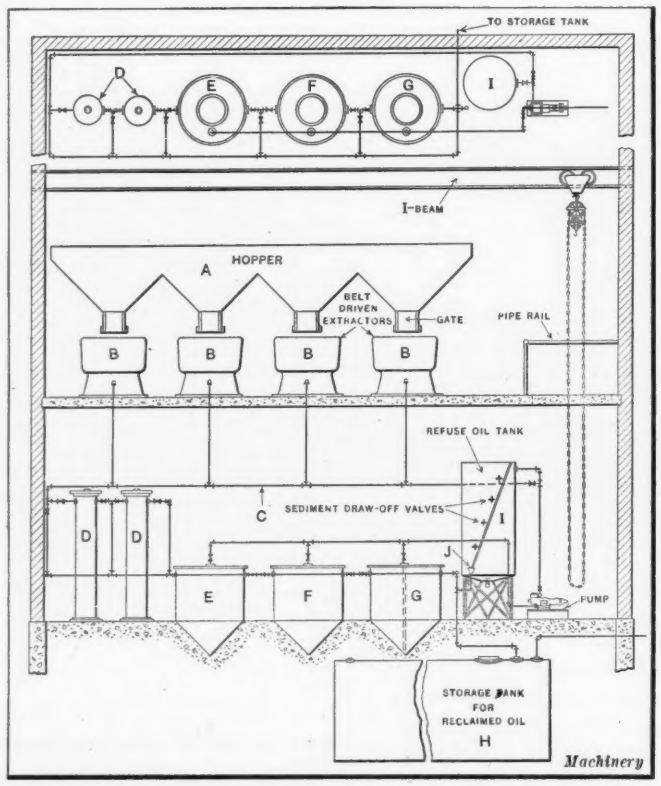



Fig. 43. Bowser Apparatus for purifying Oil recovered from Centrifugal Separators

The time required in changing dull tools will vary according to the complexity of the machine and tools; and in addition to the direct cost, there is an indirect cost through loss of production while the machine and its operator are idle. Even under the best conditions, the cost of resharpening tools is a factor of some importance. As the use of pure oil of suitable quality is the means of increasing the life of cutting tools, it will be evident that this reduces the cost of changing and resharpening tools.

The power required to drive the machines is reduced by increasing the speed at which they are driven, but it is only possible to take advantage of this condition when the cutting tools are kept sharp, which, in turn, requires the use of a suitable lubricant, kept in good condition through proper filtration. The

[1] Associate Editor of MACHINERY.

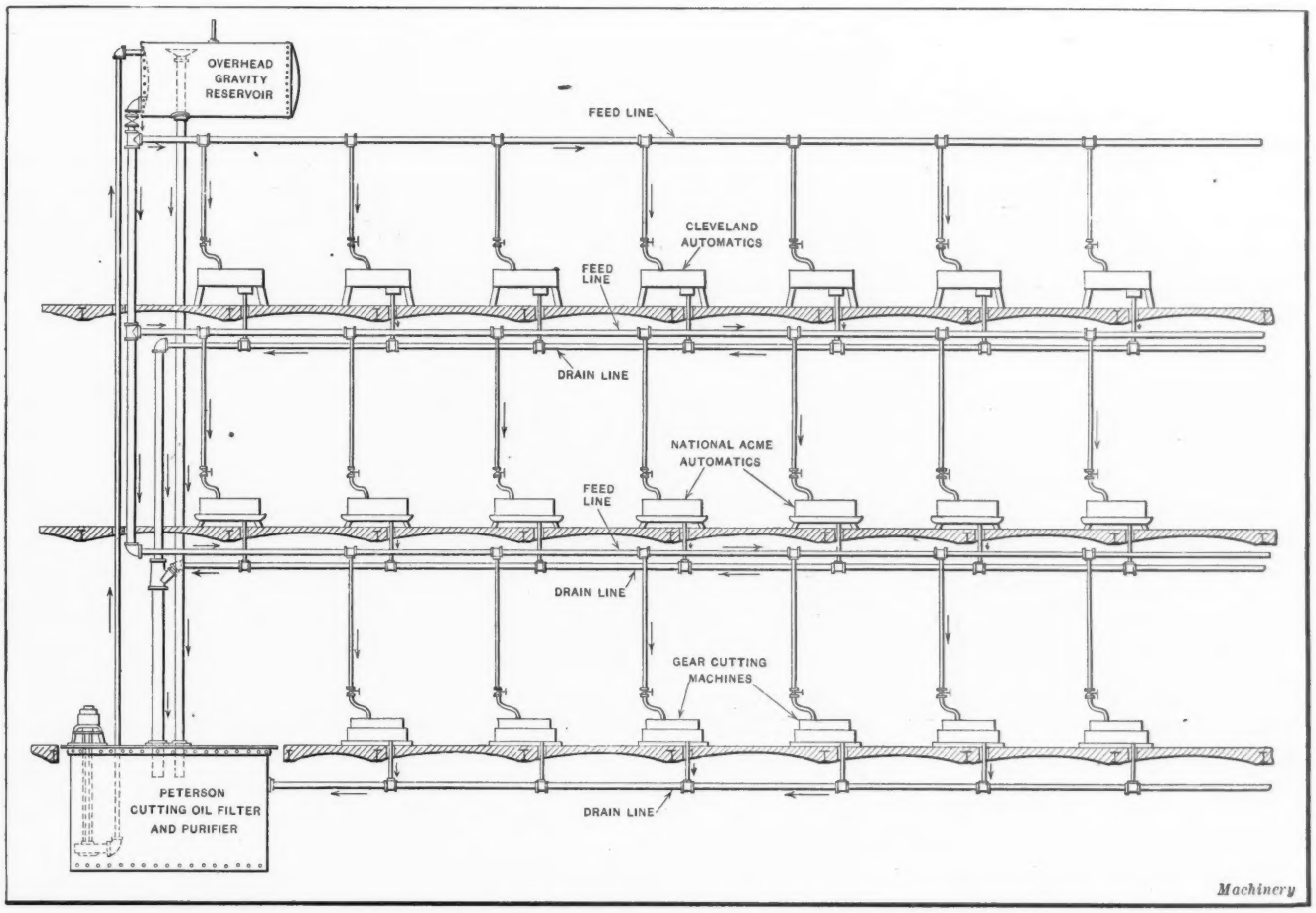



**Fig. 44. Arrangement of Complete Central Station and Piping for Distribution and Purification of Oils and Cutting Compounds—the Richardson-Phenix Co., who built this Equipment, now favors Delivery of Fluid to Machines direct from Pump, instead of using Gravity Tank System illustrated, but there are still many Advocates of the Gravity Tank**

saving of power effected through the use of good cutting lubricants is dealt with in detail later. The cost of steel for cutting tools is directly controlled by the amount of service obtained between grindings, which depends largely on the quality of oil or cutting compound, as previously explained.

### Filtration of Oil Recovered by Centrifugal Separators

Fig. 43 shows an apparatus for the purification of oil recovered from centrifugal chip separators, which was designed and built by S. F. Bowser & Co., Inc., Fort Wayne, Ind., for installation in the plant of the Timken Roller Bearing Co., Canton, Ohio. It will be seen that hopper *A* is furnished with chutes for delivering chips into the baskets of separators *B*, the hopper being so arranged that chips may be delivered to it by a container carried on a trolley. The separators are placed on the second floor of the building in order to facilitate shoveling the cleaned chips into a car for shipment. Oil from the separators is carried down into header *C*, which delivers it into heating cylinders *D*, which are connected in series; in each case the pipe leading into the cylinder extends down to a point close to the bottom and the oil flows up through the cylinder and out by way of a pipe near the top. Each cylinder is furnished with a steam coil, so that the temperature of the oil is raised to about 170 degrees F. It will be noted that a by-pass is provided to allow one or both of the cylinders to be cut out of the system if necessary.

The heated oil next flows through tanks *E*, *F* and *G*, which are connected in series, the oil being delivered into each tank through a pipe extending down almost to the apex of the conical bottom and escaping through a pipe near the top of the tank. Tanks *E* and *F* provide for the settling out of chips and other foreign matter held in suspension in the oil, while tank *G* is furnished with a steam coil to provide for raising the temperature of the oil to 200 degrees F. in order to sterilize it. The rate of flow is so adjusted that the oil is held in tank *G* for fifteen minutes, which is regarded as sufficient

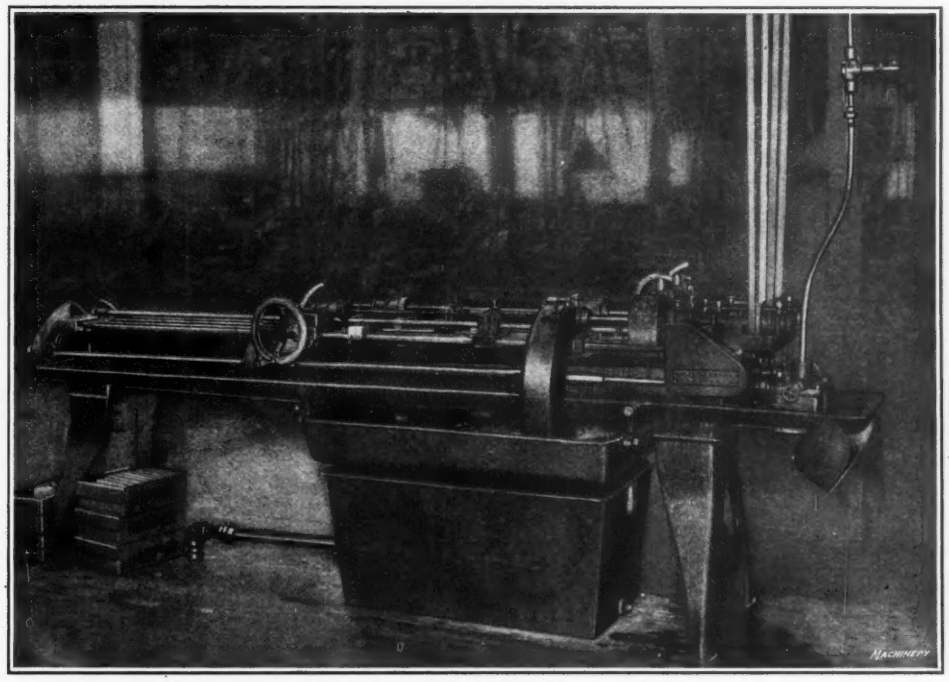


**Fig. 45. Arrangement of Piping that delivers Lard Oil to Rifle-barrel Drilling Machine and carries away Oil to Drains in Floor that return it to Filter**

time to effect complete sterilization. Clean oil from the tanks flows into storage tank *H*, from which it is pumped back to the machines. Refuse oil from the conical bottoms of tanks *E*, *F* and *G* is pumped into tank *I*, in which it is allowed to stand for a sufficient length of time to allow impurities to settle to the bottom. It is then possible to draw off the better grade of oil through cocks which deliver it into funnel *J*, carried on a pipe connection to the header leading to storage tank *H*. About 75 per cent of the oil recovered from tank *I* is suitable for use on metal-cutting tools, and the remainder of the oil is used on machinery which is of such a character that a poor grade of lubricant can be employed with satisfactory results.

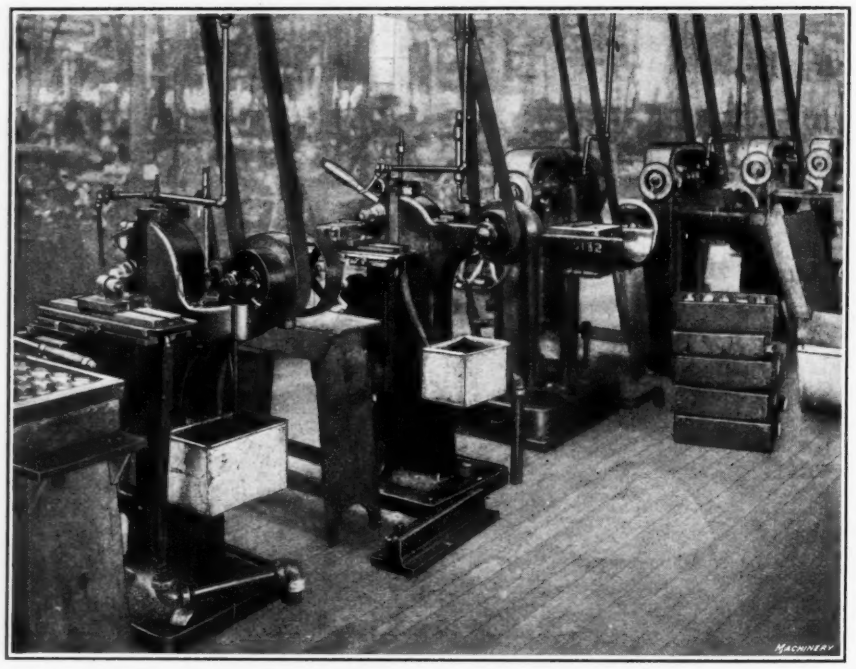


Fig. 46. Battery of Hand Milling Machines supplied with Cutting Compound through Pipes from Central Distributing Station; Compound is returned to Filter through Drain Pipes

### Practice of Nash Motors Co. in Purifying Cutting Oil

The Nash Motors Co., successor to the Thomas B. Jeffery Co., Kenosha, Wis., is using an interesting equipment for the purification of oil recovered by the use of centrifugal chip separators. The oil from the chip separators passes into a settling tank in which coarse dirt and chips are precipitated. From the settling tank the oil runs by gravity through a pipe into a storage tank, from which it is pumped into four settling tanks. These tanks are provided with steam coils, which raise the temperature of the oil to about 240 degrees F., at which it is held for one hour, after which the oil is allowed to stand for from twelve to twenty-four hours to allow all impurities to settle to the bottom.

The centrifugal chip separators are driven by steam turbines, which pass exhaust steam into the chip baskets to facilitate the separation of oil, and in so doing the oil becomes mixed with water that must be removed before it is returned to the machine tools. This is done by passing the oil into a battery of three centrifugal cream separators, from which the pure oil is collected in steel barrels. These barrels are carried through the shop on trucks and the oil is pumped into tanks on the machines by means of hand pumps on the barrels.

Oil carried away by chips and recovered through the use of centrifugal separators usually contains many impurities such as particles of iron oxide, fine chips, etc., which makes careful filtration a matter of great importance. In place of the methods of filtration that have been described in the foregoing, some manufacturers have found that it is better practice to use horizontal filter presses for cleaning oil recovered by centrifugal chip separators. In these presses the fluid to be purified is passed through a series of porous diaphragms, supported in a horizontal frame; and to increase the rate of filtration, pressure is applied to the fluid by a plunger operated by a capstan wheel and screw or other suitable means. Experience has shown that if finely ground Fuller's earth, kieselguhr, or similar mineral matter is added, this material will build up on the diaphragms of the filter and form a porous structure that constitutes a highly efficient filtering medium. Oil purified in this way is often superior in quality to the original oil shipped from the refining plant.

### Importance of Filtering Oil or Cutting Compound

Where it is not the practice to filter the oil or cutting compound used on machine tools, impurities carried in suspension

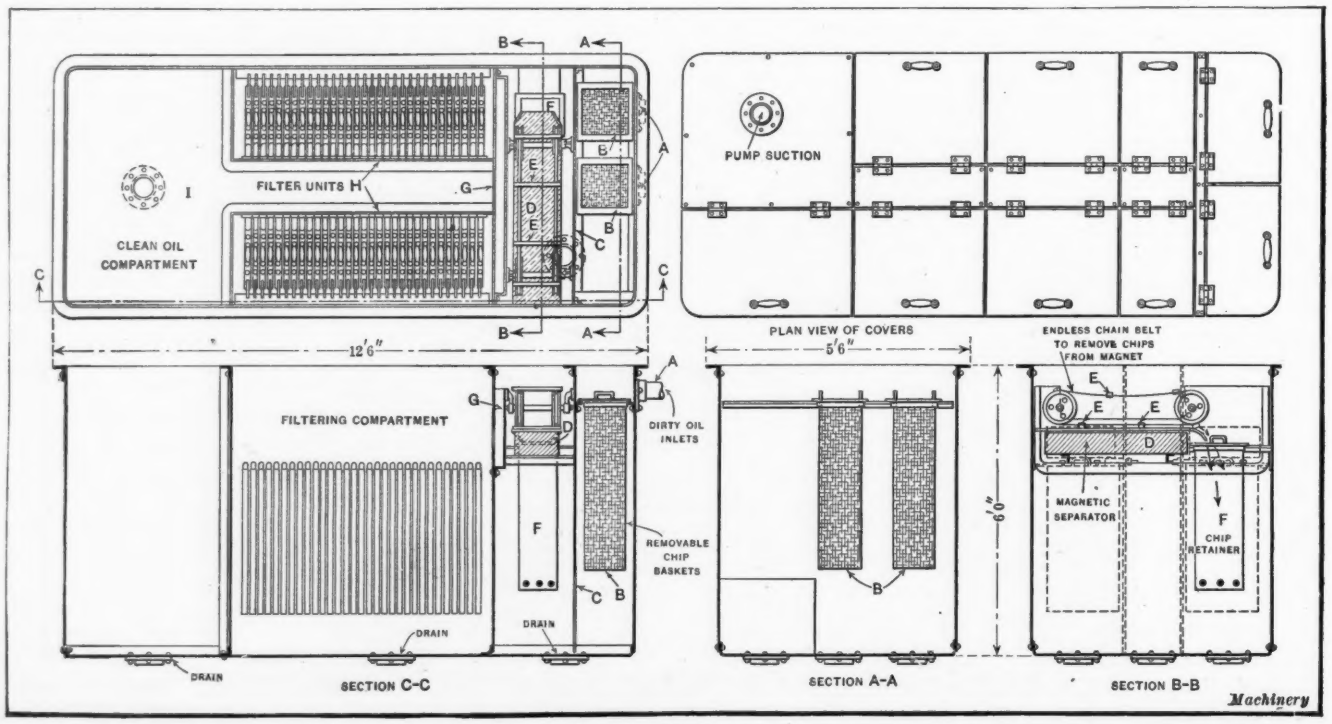



Fig. 47. Petersen Filter and Purifier built by Richardson-Phenix Co., showing Arrangement of Chip Baskets, Baffle Plates, Magnetic Separator and Filtering Units

by the oil are likely to cause trouble in a number of ways. One of the commonest of these is the damage done to machine-tool slides and bearings through particles of oxide scale and small metal chips. In some cases these impurities exert a harmful effect upon the finish produced by the tools. They also cause trouble through scoring the cylinders of pumps used for circulating oil on individual machines or for distributing it from a central station to all the machines in the factory.

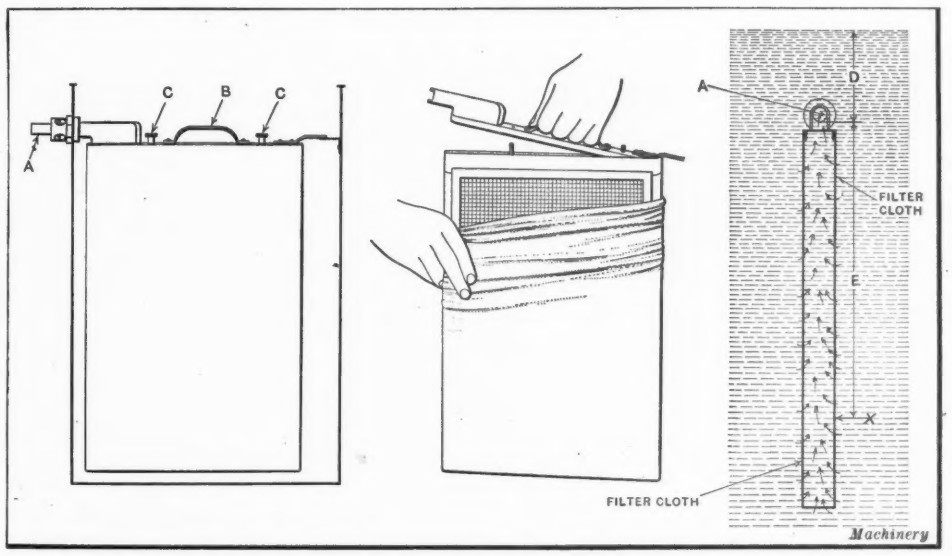



Fig. 48. Close View of Filtering Unit, showing Method of removing Cloth Bag for cleaning, and Diagram showing that Mean Effective Pressure is the Same all over Surface of Filtering Unit

Particles of metal suspended in the oil delivered to cutting tools will sometimes cause the most unexpected difficulties, of which the following is a typical example. In a certain shop it was the practice to manufacture a brass product on automatic screw machines, and when the demand for these brass parts had been temporarily filled, the machines were switched over for operation on a product made from steel bars. In the latter case high-speed steel cutting tools were used. When changing over the machines, all chips were removed from the pans, but the same cutting oil was used on both steel and brass products; and the oil recovered from either the brass or steel chips sent to the centrifugal separator was returned to the reservoirs in the automatic screw machines.

Occasionally it was found that the high-speed steel tools that had formerly been giving satisfactory service in producing the steel product would suddenly commence to tear the metal and produce an unsatisfactory finish. A careful investigation showed that this trouble was caused by small particles of brass carried by the oil, which had been used on the tools for machining the brass product. These particles of brass tended to pack on the cutting edge of the high-speed tools, and the high temperature of these tools resulted in partly fusing the brass, with the result that it eventually covered the cutting edge and made the tool dull. To the naked eye nothing was visible, but when examined under a strong magnifying glass the accumulation of brass on the tools was seen to be very pronounced. After an effective filtering system was installed these particles of brass were removed from the oil and no further trouble of this kind was experienced.

### Central Distributing Station for Oils and Cutting Compounds

The importance of delivering clean oil to metal-cutting tools has long been recognized, but recently the development of means for oil purification has been carried further than was possible with the form of strainers and distributing equipment furnished on individual machine tools. Many large manufacturing plants are now being furnished with central distributing stations from which cutting oils and compounds are delivered to all machines in the factory by a permanent pipe system, and similar systems of drain pipes carry the lubricant back to the central station where it is purified for subsequent use. Such an arrangement is shown diagrammatically in Fig. 44; and Figs. 45 and 46 show the piping that carries the lubricant to a rifle-barrel drilling machine and several hand milling machines. Figs. 45 and 46 also show drain pipes that carry away the fluid. Not only does this provide better facilities for the purification of used oil, but it also saves labor costs in handling oil and assists in maintaining sanitary conditions in the factory.

The Richardson-Phenix Co. of Milwaukee, Wis., specializes in the construction of systems for the distribution of oil or cutting compound from a central station to all the machines

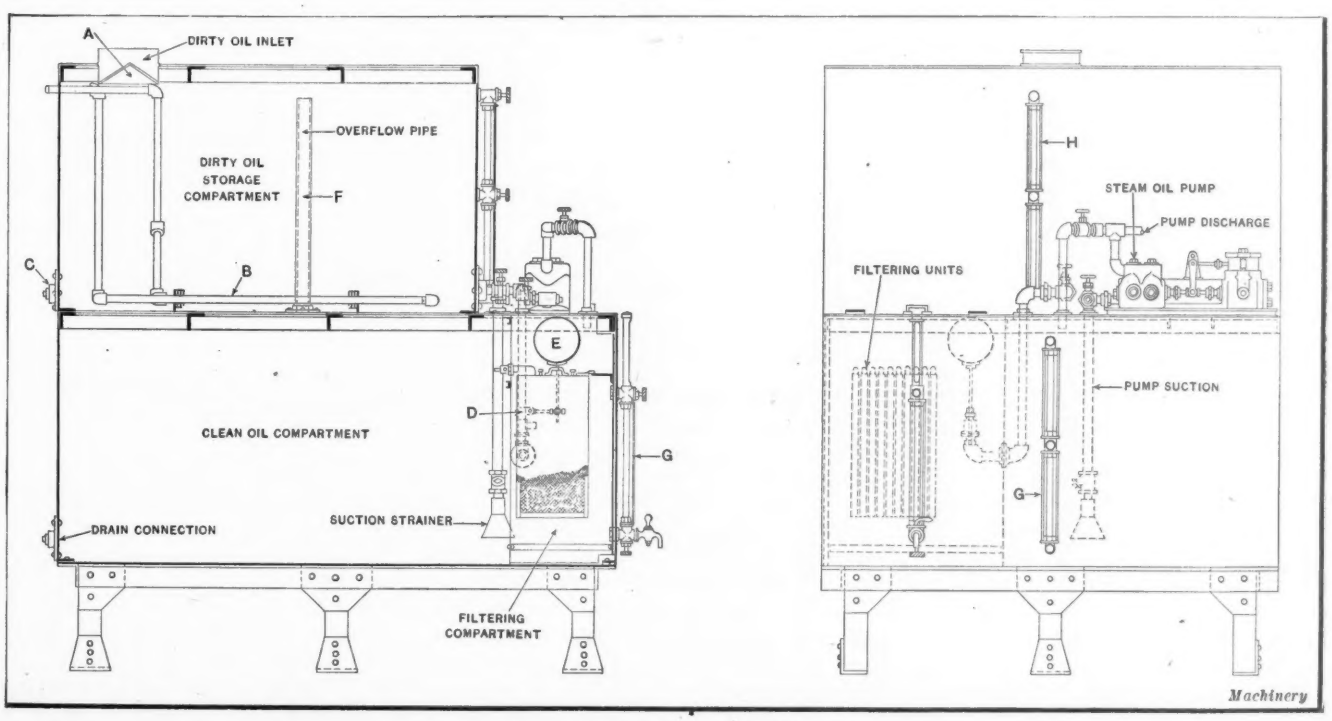



Fig. 49. Richardson-Phenix "Batch" Filter

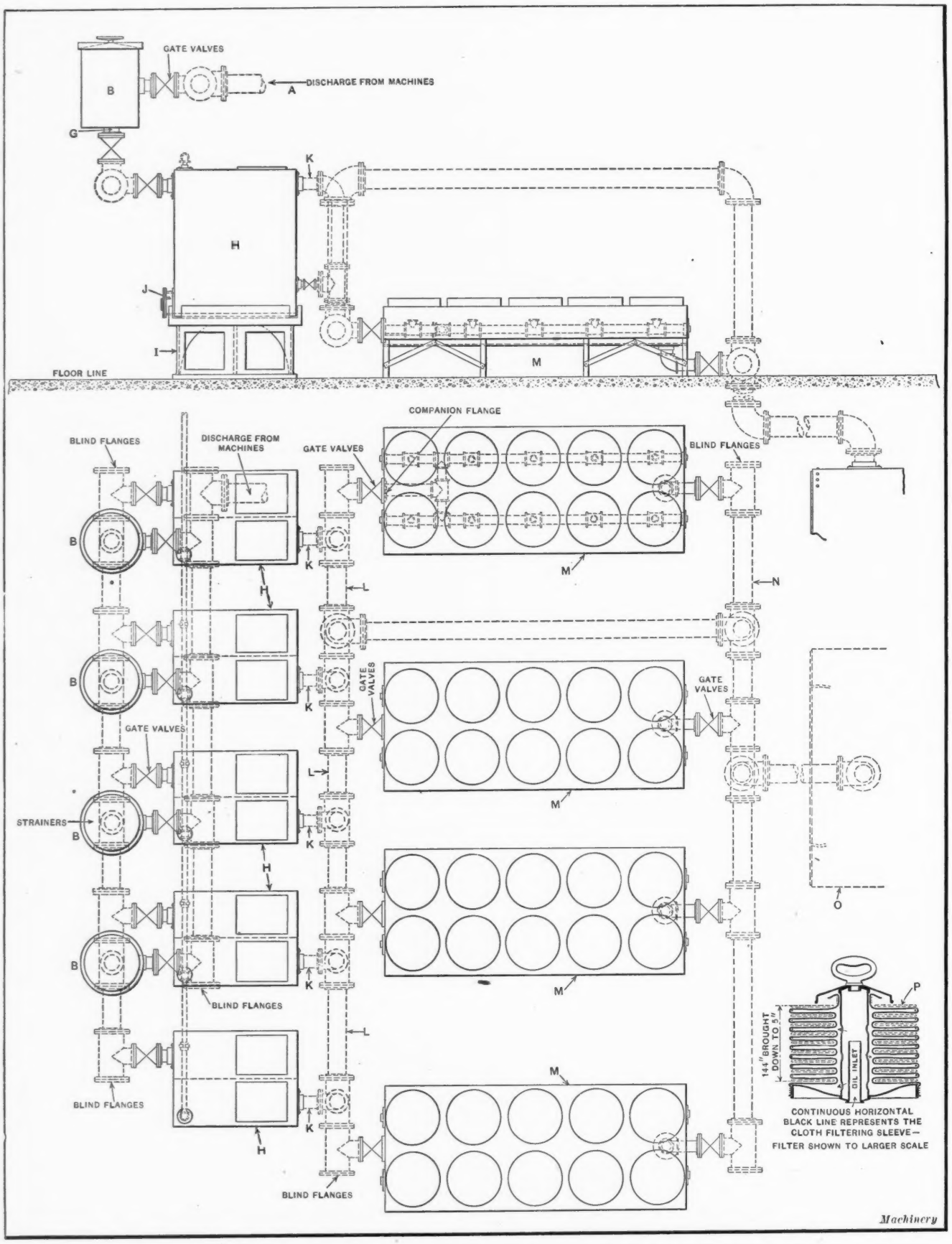



Fig. 50. Oil Reclaiming System built for Remington Arms & Ammunition Co. by S. F. Bowser & Co., Inc.

in the factory, the collecting and returning of this oil to the central station and its purification. This company's system of purification provides for passing the oil through a series of apparatus for the removal of foreign matter carried by the oil; in all cases the equipment is built to meet the special requirements of the plant in which it is to be used, and the means provided for purifying the lubricant will naturally vary in different cases. Fig. 47 shows one of the more complete equipments, from which a good idea may be obtained of the way in which the Richardson-Phenix system is applied. Used oil enters inlets *A* and passes down through strainer baskets *B*, which remove the coarse chips and other impurities. The fluid then flows under baffle plate *C* and up across the top of magnetic separator *D*, where the iron or steel chips are removed. Scrapers *E*, operated by an endless chain belt, travel across the face of this magnet and scrape off the chips into retainer *F*, which is provided with screened holes in the bottom to allow the oil to drain out. Reference to the cross-sectional view on line B–B will show that this chip retainer can be slid to the right and lifted from the tank to empty the

chips. After passing over the magnetic separator *D*, the lubricant flows across dam *G* into the filtering compartment, from which it passes through cloth-covered filtering units *H*, where the most finely divided particles of foreign matter are removed; the clean oil is collected in compartment *I*, from which it is drawn off through the pump suction pipe.

It will be noticed that a large number of filtering units *H* are employed in the system shown in Fig. 47, and the number of these units determines the filtering capacity; as it is possible to provide tanks with the desired number of units, the system is readily adapted to the capacity requirement of the factory in which it is to be used. Fig. 48 shows detail views of one of these filtering units and also the means provided for cleaning it. It will be seen that it consists of a cage covered with galvanized wire mesh over which a cloth bag is tightly stretched so that it is free from folds, which retard filtration. Oil passes into these filtering units from the outside and clean oil escapes through discharge pipe *A*. These discharge pipes fit into automatic valves, and when it is required to remove a unit from the tank it is merely necessary to take hold of handle *B* and slide the unit to the right, with-

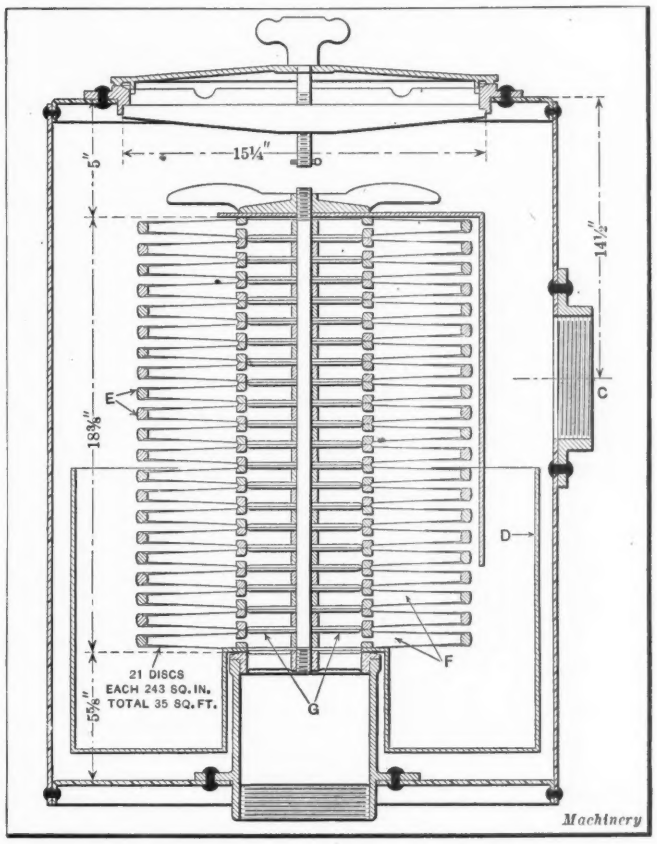



Fig. 51. Detail of Strainer Box used in Oil Reclaiming System shown in Fig. 50

drawing discharge pipe *A* from the valve, which then closes automatically. In many cases the only cleaning required is to brush off any dirt which has collected on the cloth. When it is desired to substitute a fresh bag on the unit, thumb-nuts *C* are removed and the top of the filtering unit is lifted off, as shown at the center of Fig. 48; this releases the top edge of the cloth bag, which may be drawn down as shown in this view. Attention is called to the fact that the edges of the filtering units are made perfectly smooth so the bags will slide easily over them.

An important consideration of passing oil or cutting compound through this form of filter is that the net pressure on the filter cloth is equal to head *D*, regardless of where point *X* is assumed; thus every square inch of surface at any point *X* is subjected to the same degree of pressure tending to force the fluid out through discharge pipe *A*. It will be evident that filtering cannot begin until the level of the oil has reached discharge pipe *A*, thus insuring a uniform effective pressure over the entire surface of the filtering unit. This effective head *D* is usually maintained at about three inches; and although the capacity of the filters could be greatly increased by carrying a head of two or three feet,

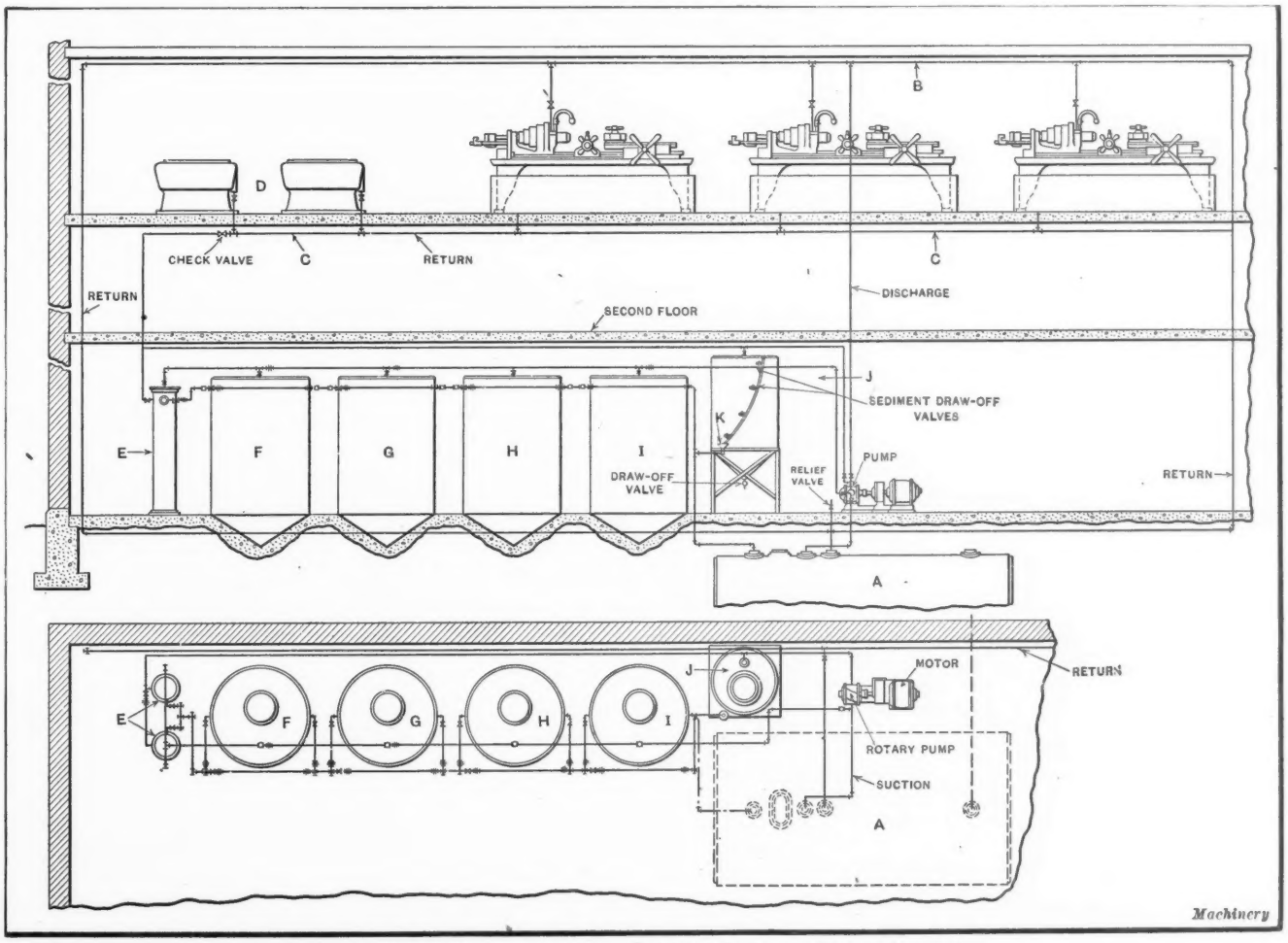



Fig. 52. Oil Reclaiming System in which Oil is heated to facilitate Sedimentation

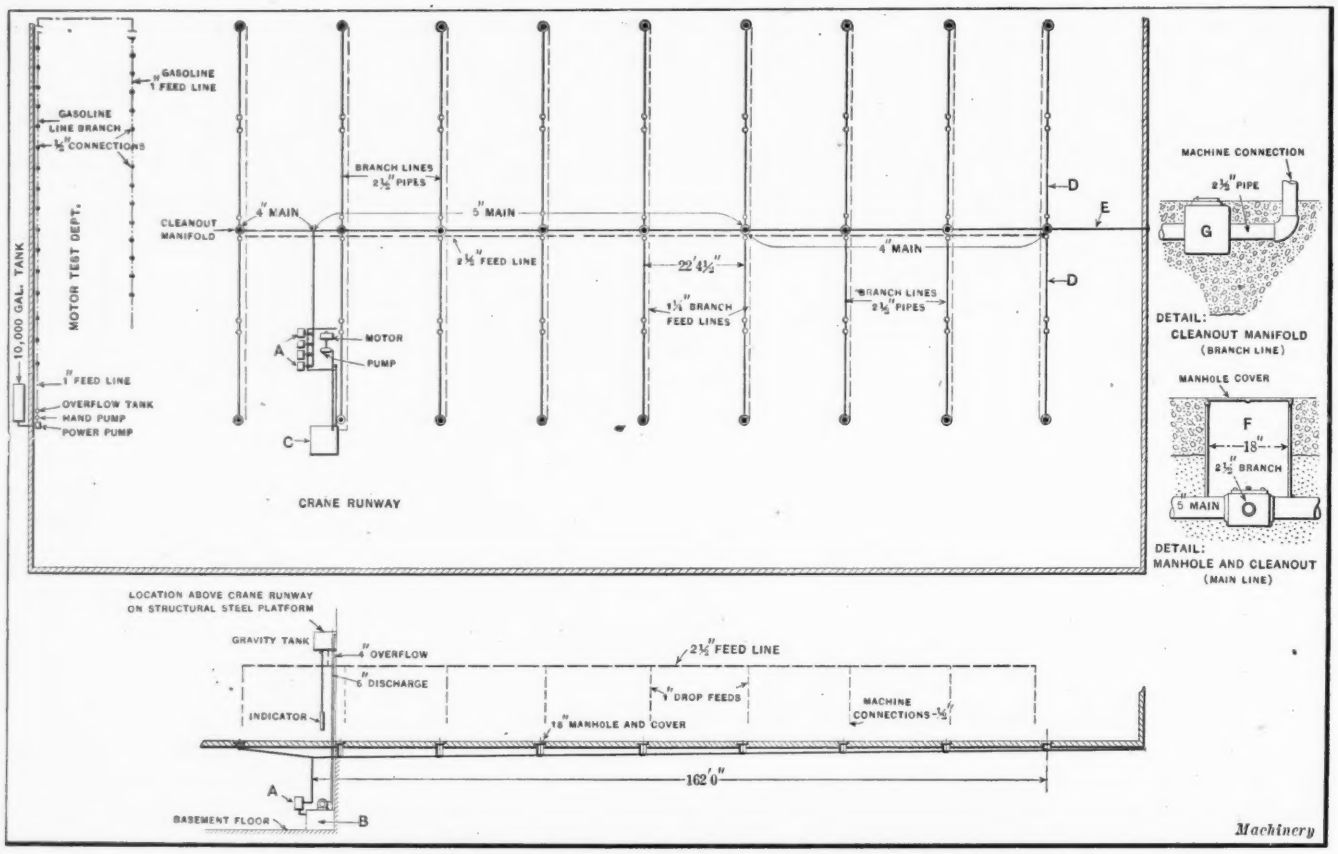



Fig. 53. Bowser Equipment for purifying Emulsions made from Soluble Oil and Water

the pressure developed would be likely to force fine particles of dirt through the filter, thus lowering its efficiency. An important advantage of having the filtering units held in a vertical position, with the oil passing from the outside to the inside, is that slime and sediment held by the cloth tend to drop off and settle at the bottom of the tank.

### Equipment for Conducting "Batch" Filtration

A different arrangement of Richardson-Phenix filter tank and sterilizer is illustrated in Fig. 49. A quantity of used oil from the machines is run into the "dirty oil storage compartment" through removable strainer *A* that catches all coarse chips and dirt. While held in the dirty oil compartment a portion of the foreign matter in suspension in the oil settles to the bottom and may be flushed out from time to time through draw-off *C*. Oil flows through a float-controlled valve *D* into the filtering compartment, which is equipped with cloth-covered filtering units like those previously described. Control of the rate at which oil flows into the filtering compartment is obtained by regulating the position of float governor *E* on the stem of valve *D*. In this way a head of oil of from one to six inches above the filtering units may be maintained, and this controls the rate at which filtration takes place. To secure the best results, the float valve should be adjusted so that the filter handles the oil as slowly as possible and still maintains the desired capacity.

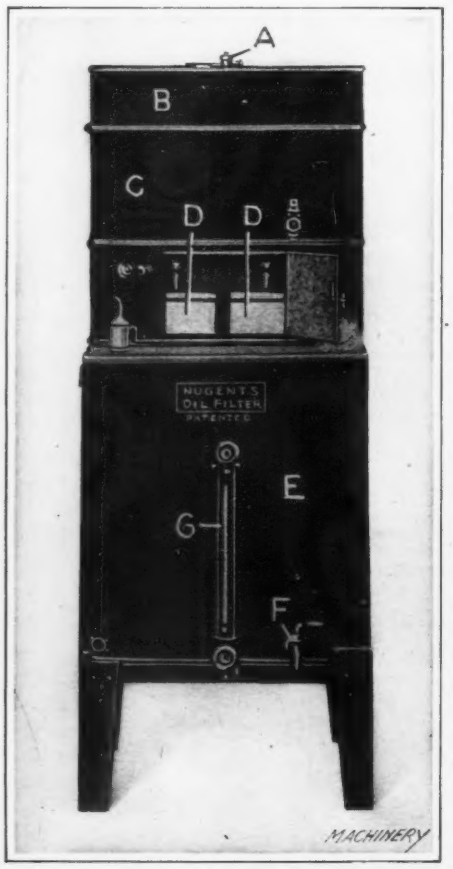



Fig. 54. Oil Filter made by William W. Nugent & Co.

When it is necessary to sterilize the oil, steam is turned into coil *B* in the dirty oil compartment, and after passing through the filtering units into the "clean oil compartment," the oil is pumped back into the upper compartment. This circulation of the oil is continued until the temperature of all the oil has been raised to 140 degrees F., and it is held at this temperature for twenty minutes.

It will be seen that there is an overflow pipe *F* in the upper compartment, and if the level of the oil reaches the top of this pipe, it runs over into the lower compartment. This is merely a safeguard against the overflow of oil onto the floor. In practice, float-valve *D* is regulated so that the filters will carry away the oil as fast as required. At the front of the filter there are gage glasses *G* and *H* which show the level of oil in the lower and upper chambers. These glasses are protected by white enameled sheet metal reflectors. This system is known as "batch" filtration and sterilization because all the dirty oil is drawn from the machines and a new lot of clean oil substituted, the batch of dirty oil being taken to the filter and put into condition to be used subsequently.

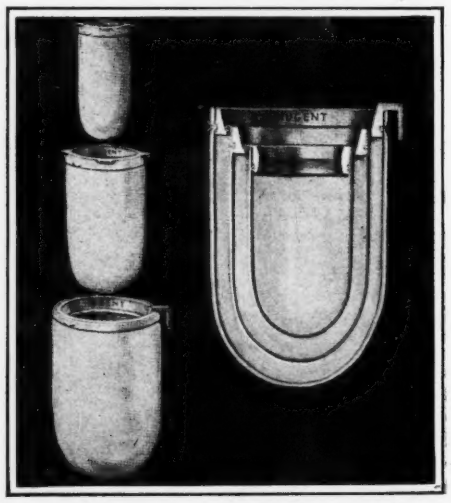



Fig. 55. Detail of Filtering Bag used in Equipment shown in Fig. 54

### Bowser System of Oil Purification

In the systems built by S. F. Bowser & Co., Inc., Fort Wayne, Ind., for the filtration

and sterilization of oils and cutting compounds used on machine tools, the principles employed are somewhat different from those that have already been described. In the type of equipment generally used, dirty oil returned from machines is first run into large settling tanks, where its temperature is raised by heat supplied from steam coils. This serves to make the oil more fluid and facilitates the settling out of impurities; in addition, the temperature may be raised sufficiently to provide for sterilizing the oil before it is passed on through the filtering units.

Probably the best way to describe the manner in which a Bowser system is operated will be to describe in detail one or two typical installations. In all cases the systems are designed and built to meet existing requirements in the factory, but there are certain established principles on which all of these operate, and the examples selected are typical of this firm's practice. Fig. 50 illustrates an oil reclaiming system built for the Remington Arms & Ammunition Co., Bridgeport, Conn., which has a capacity for handling 24,000 gallons per hour. Dirty oil enters through pipe *A* and is passed through strainer boxes *B*, in which most of the coarse dirt is removed. A cross-sectional view of one of these strainer boxes is shown in Fig. 51, and it will be well to explain how this operates. The oil to be purified enters the strainer box at *C*, and passes down through a chip basket *D*, which collects the larger chips and coarse dirt that have passed through the strainers in the machine-tool oil pans. At the center of the chip basket will be seen twenty-one disks *E*, which consist of iron frames covered with 1/16-inch wire mesh. It will be apparent from the illustration that these disks are so arranged that oil which enters the strainer box passes through the wire mesh into channels *F* leading to a central duct *G*. The purpose of the multiple disk construction is to provide a maximum straining surface so that oil may be passed through the box as rapidly as possible. From duct *G* the oil passes on to subsequent parts of the system through which it passes during the process of purification. In order to clean one of these boxes, the cover is removed to enable the set of disks and the chip basket to be lifted out. It will be seen that the disks are clamped together by a central rod, and that a shield is provided at the front of opening *C* to prevent excessive pressure from driving dirt through the filtering screen at this point.

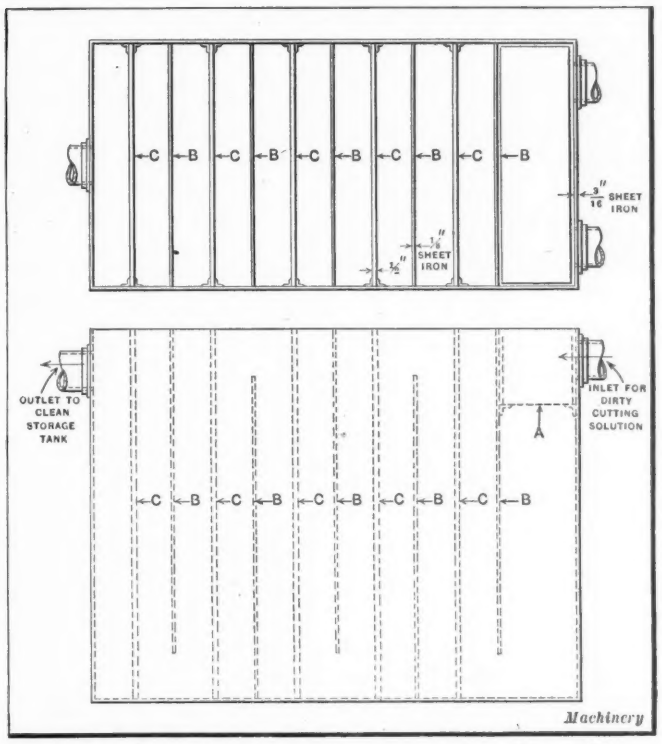



Fig. 56. Filter designed by Marlin Arms Corporation for purifying Cutting Compound used in its Factory

In Fig. 50, connection *G* leads from the lower end of the central duct in the strainer boxes through which oil is discharged into magnetic separating tanks *H*. The design of these tanks is quite different from the settling tanks commonly used in Bowser oil reclaiming systems. Instead of being furnished with steam coils for heating the oil to facilitate sedimentation, these tanks are provided with electromagnets mounted in the cast-iron bases *I*, which cause the chips to be quickly drawn to the bottom of the tanks. As a result, the oil can be handled in this system much more rapidly than where it is necessary to wait for impurities to settle to the bottom of the tanks. Unless special provision were made for overcoming trouble from chips becoming magnetized and sticking to the bottom of the tanks, it would be exceedingly difficult to clean out the accumulation of chips. This is provided for by making the bottom of the tanks of brass, which is non-magnetic, so that when the current is turned off from the electromagnet, the chips may be easily raked out through two clean-out doors *J* in each tank.

From magnetic separating tanks *H*, the oil passes through pipes *K* into header *L*, which is connected with a battery of four filter tanks. The Bowser filters consist of cloth sleeves held by clamps at top and bottom to metal frames. The oil is delivered to the filters by pipes communicating with header *L*. The only outlet is through the cloth sleeve of the filter units and in flowing through this cloth, fine particles of metal and other foreign matter carried by the oil are removed. The filter sleeves can be removed from the metal frames and washed when necessary. The clean oil escapes into filter tanks *M*, which are connected with header *N* that carries it to storage tank *O*, from which it is pumped back to the machines. A filter of the type used in tanks *M* is shown in detail at *P*.

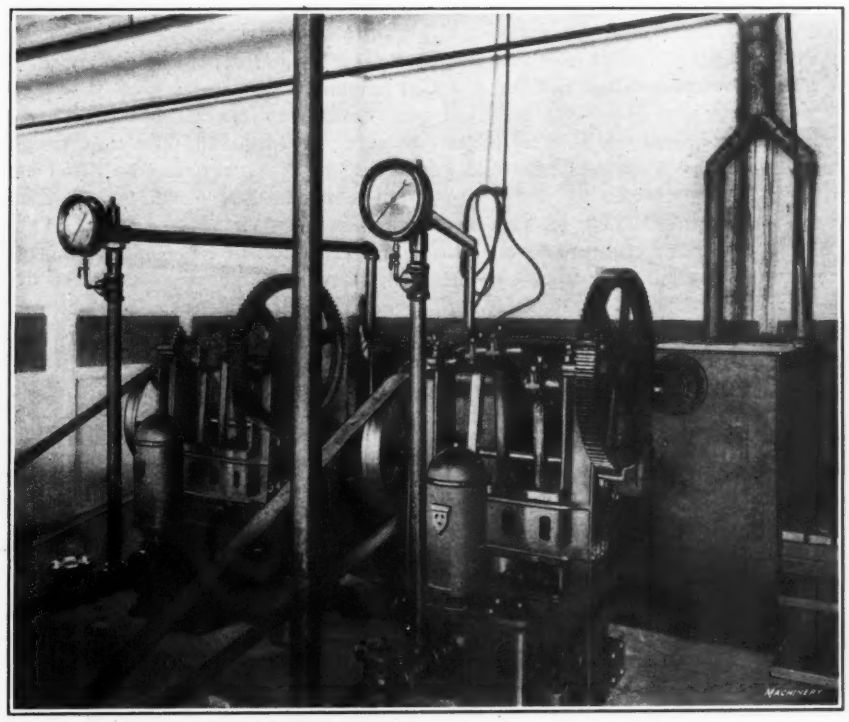


Fig. 57. Filter shown in Fig. 56; also Pumps, Pressure Gages, Storage Tank, etc.

### Use of Heat to Facilitate Sedimentation

In the preliminary statement that was made concerning the principles governing the operation of Bowser oil reclaiming systems, the fact was mentioned that a practice is often made of running the dirty oil into settling tanks in which the temperature of the oil is raised by steam coils in order to facilitate the settling out of impurities held in suspension, and also to provide for sterilizing the oil. A good arrangement of such a system is illustrated in Fig. 52. In this system oil is pumped from storage tank *A* to headers *B*,

from which connections are carried down to the machine tools. Drain pipes from chip pans on the machines carry the used oil to return pipes *C*, which deliver it back to the settling tanks and thence to storage tank *A*. In a previous section of this article, attention was called to the importance of recovering oil from chips, and at *D* in the present illustration is shown the manner in which oil from the centrifugal separators is delivered into return pipes *C*.

The first step in purifying the oil consists of passing it through two heaters *E*. These are merely vertical cylinders connected in series. The oil is delivered at the bottom of the first cylinder and flows up over the steam coil and thence into the second cylinder, where it passes over another steam coil, the temperature of the oil being raised in this way to about 170 degrees F. From heaters *E* the oil is delivered into tanks *F*, *G*, *H* and *I*, which are connected in series by pipes that carry the oil down into each tank to a point close to the conical bottom and allow it to escape into the next tank through a pipe placed close to the top. This affords the most favorable condition for allowing impurities in the oil to settle to the bottom of the tank. Tanks *F* and *G* are settling tanks, that is to say, their function is to allow the bulk of chips and other suspended impurities to settle out from the heated oil. Tanks *H* and *I* are sterilizing tanks and are arranged with steam coils that provide for raising the temperature of the oil to about 200 degrees F. The rate at which the oil flows through the tanks is so adjusted that it takes about thirty minutes for it to flow through all four tanks; in other words, it takes fifteen minutes to flow through tanks *F* and *G*, in which sedimentation takes place, and fifteen minutes to pass through sterilizing tanks *H* and *I*. From tank *I* the oil is carried down into storage tank *A*, from which it can be withdrawn for subsequent use.

Oil that collects in the conical bottoms of the settling tanks is of poor quality, owing to the fact that it contains practically all of the suspended matter originally carried by the entire volume of oil passed through these tanks. This oil requires further treatment before it is fit to be delivered to the cutting tools, and this treatment is obtained by pumping it into cylindrical tank *J*, in which it is allowed to stand for a sufficient length of time to allow the impurities to settle to the bottom. It will be seen that there are four draw-off cocks on tank *J*, and after the oil has been allowed to stand for a sufficient length of time to insure that the impurities have settled, the upper cocks are opened one at a time, to allow it to flow into funnel *K*, which is carried at the top of a pipe connecting with the pipe line leading to storage tank *A*. The oil which is recovered in this way will ordinarily amount to about 75 per cent of the oil pumped into tank *J*, although the quantity will vary according to the quality of the oil and the service in which it has been used. The poorest grade of oil drawn off from the lowest cock is unsuitable for the lubrication of cutting tools, and this is usually employed for oiling conveyor chains, and other classes of service where a poor grade of lubricant may be used.

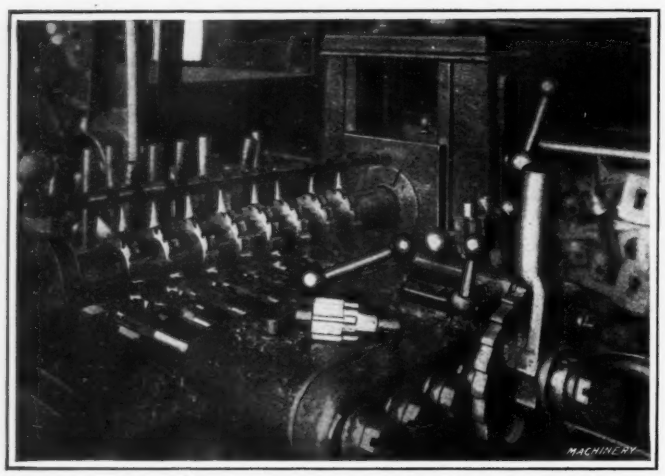


Fig. 58. Coolant applied to Eight Cutters on Multiple Gear-cutting Machine

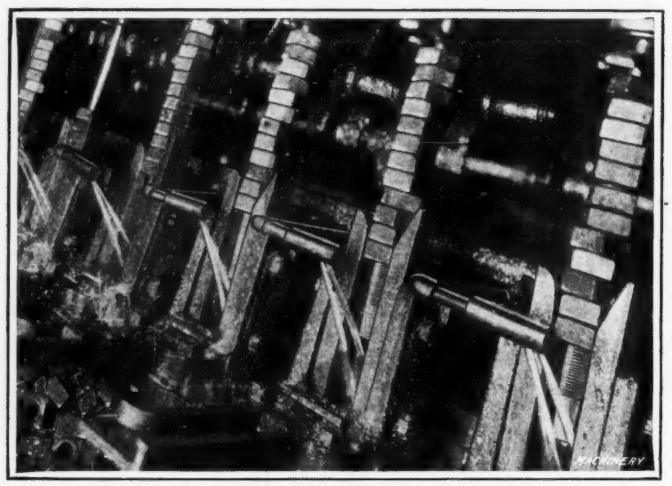


Fig. 59. Delivery of Cutting Solution to Multiple Nut-tapping Machine

### Purification of Soluble Oil Compounds

The purification of emulsions made by the mixture of so-called "soluble" oils with water does not generally require as careful attention as the more viscous oils used on cutting tools when both lubricating and cooling are necessary. This is due to several causes, among which is the fact that emulsions are more fluid than oils and so do not tend to hold such a large quantity of chips and particles of scale in suspension. Another important consideration which simplifies the purification of cutting emulsions is that they are usually employed on those classes of work where it is merely necessary to cool the tools, and as no lubricating action is necessary the presence of fine chips and dirt is not a serious detriment.

Because of these considerations, a much more simple equipment is often employed for the purification of emulsions, and Fig. 53 shows an outfit built by S. F. Bowser & Co., Inc., for this class of service, the system illustrated being used in the plant of the Pittsburg Model Engine Co., Pittsburg, Pa. This illustration shows a plan view of the drain pipes into which the fluid is delivered from pans on machine tools, the fluid being carried to a battery of four strainer boxes *A* of the type described in detail in connection with Fig. 51. After passing through these boxes, the purified emulsion goes to drain tank *B*, from which it is pumped back to gravity tank *C* that delivers it to all of the machines in the factory.

At each intersection of the cross drain pipes *D* on the main header *E*, there is a "cross" which is provided with a cover that may be taken off to facilitate clearing away any stoppage that may occur in the drain pipes. When large chips find their way into the pipe line it is possible for an accumulation of these to gather and cause the pipe to be blocked up; and if trouble of this sort occurs, it is merely necessary to remove the cover from the "cross" and push through a piece of wire to carry the chips and dirt that are giving trouble to the next "cross" so that they may be lifted out. This arrangement is shown in detail at *F*, which also illustrates the manhole provided in the floor to give access to the piping. In this detail illustration it will be seen that the piping is located at a considerable depth below the surface of the concrete floor, this being necessary in order to give the piping the required pitch to cause the compound to run off with the desired rapidity. At *G* is shown the type of box with a removable cover that is provided at the end of each cross drain pipe.

### Nugent Oil Filters

William W. Nugent & Co., Chicago, Ill., manufacture oil filters of the type shown in Fig. 54. This type is made in three sizes, having capacities for handling four, six and twelve gallons per hour. Such filters could be used to advantage in filtering oil recovered from centrifugal separators or for reclaiming dirty oil taken from the pans of machine tools. Oil enters the filter at *A* and passes through a wire mesh strainer in upper compartment *B*, that removes the coarse material from the oil. It then flows into a settling tank *C* in which a further purification is effected. From tank *C* the oil flows

through pipes that discharge into filter bags *D*, each pipe being provided with a shut-off cock. There are three bags in each set, which are made of cloth of different degrees of fineness; and these bags are supported on metal frames in such a way that the bags in any one set do not come into contact with each other. This arrangement is shown in detail in Fig. 55. The filtered oil is collected in storage tank *E*, from which it is drawn off through cock *F*; and a gage glass *G* shows the level of oil in the tank.

The Nugent filters are also made in larger sizes capable of handling the oil or cutting compound used in large shops. These large filters are equipped with any required number of filter bags to provide for taking care of the volume of oil to be purified.

### Simple Filter for Cutting Compounds

In the plant of the Marlin Arms Corporation, New Haven, Conn., a Richardson-Phenix filter is used for the purification of lard oil supplied to rifle-barrel drilling machines and certain other machines in the factory. For the purification of soluble cutting compounds used on milling machines, drill presses, and some other classes of machine tools, a simple filter was designed and built in the Marlin factory. As shown in Figs. 56 and 57, this filter consists of a sheet-metal tank with a chip basket *A* through which the compound flows to remove coarse chips. Five baffle plates *B* cause the fluid to follow a winding course in order to facilitate the settling of small chips and other impurities held in suspension. Between each of these baffles there is a wire screen *C* held between angle-irons so that it may be lifted out for cleaning. It was the original plan to have each of these screens covered with muslin to provide a filtering medium, but subsequent experience has shown that the fluid passes through more rapidly if only the last two screens are covered with muslin, and this is sufficient to insure the removal of all the suspended impurities. Placed beside the filter tank there is a storage tank for clean cutting compound, as may be seen in Fig. 57.

### Improvement in Efficiency through Filtration

Any manufacturer who contemplates the installation of equipment for filtering oil or cutting compound will naturally ask the question, "How will the use of such an outfit be valuable in handling my work?" This can best be answered by citing one or two typical experiences of manufacturers who have found that trouble from rapid tool wear or poor finish is due to suspended impurities carried by the tool lubricant, and who have overcome such difficulties through the installation of an efficient system of filtration.

In the plant of the Boss Nut Co., Chicago, Ill., dissatisfaction was felt with the method of lubricating dies and cutting tools. This plant has an equipment of six punch presses of from two to five tons each, and one twenty-ton press; also six nut tappers, having six spindles each. The plant manufactures square and hexagon nuts, which are stamped out of 5/16- to ½-inch metal.

The former method of lubrication was by means of a gravity tank on each press, the lubricant being fed through a ¼-inch pipe to the die, from which it dripped off into a pan underneath the press. The stampings from the presses fell into iron pails with perforated bottoms, so that the lubricant would drip off from the finished product. These pails, after standing in the pans for a certain period, were lifted out, the drippings remaining in the pans. In lifting out the pails, a certain amount of cutting compound adhered to the bottom, etc., and later dripped onto the floor around each machine. While this loss of lubricant was not great, in dollars and cents, the task of keeping the floors clean, so that the men could do their work properly, took the time of one or two men about two hours each day; besides, it required two or three men to lift the pails filled with punchings from the presses.

Small rotary pumps were used to deliver the used lubricant from the drip pans to the gravity tank; and as the fluid was used over and over again without treatment, it always contained a great deal of scale and other foreign matter. Besides, at the speed at which the machines worked, a considerable portion of the cutting compound at each machine was lost by drippage and by adhering to the finished product. It required the time of two men at least two hours each day to mix and deliver new cutting compound to the various machines; and when this lubricant became so dirty as to render it unfit for use, it was thrown away. In adding or renewing the cutting compound, the time of the operator and the machine itself was also lost, with the result that the machines were operating at a low efficiency. By the installation of a Richardson-Phenix filtering system, all these faults were overcome, and the output was increased upward of 20 per cent. This system was installed in the following manner:

Trenches were cut in the floor, under the presses, of sufficient size and pitch so that the cutting compound would drip from the machine into these trenches, which are connected by a pipe line to a centrally located cutting oil filter. The trenches are covered with grating made of ⅛- by ⅜-inch flat iron spaced ¼ inch apart. These gratings are removable, so that they can be easily cleaned; and the kegs into which the finished product drops stand on top of the gratings, so that all the drippings flow back to the filter. One of these kegs can be easily and quickly slipped out from under a press and another one inserted. This permits handling the finished product as it comes from the presses, and as one man is now able to do this work, it saves the labor of two men.

Another advantage is that the men operating the presses do not have to stop their machines to fill the gravity tank, nor do they have to pay any attention to whether the pipe leading from the oil tank is full of dirt and grease, but can concentrate all their attention on production. This is also true of the nut-tapping machines. Under the old system it often happened that the operator actually had to wait for compound to be mixed or carried to his machine. The advantage of using a clean compound on drills and taps is self-evident, and while data are not available to show exactly how much longer a tap will last when properly lubricated, this company is quite certain that it is getting longer service from the same taps than it ever got before.

Cutting compound is a mechanical mixture and not a chemical compound; therefore, rapid circulation through a central system tends to keep the compound thoroughly mixed. For this reason, this system was so designed that all the compound in the system is circulated ten times per hour, *i.e.*, the system contains 300 gallons of cutting compound, and there is circulated in the various machines 3000 gallons per hour. Hooded drains from the machines should not be used, because if the oil in the compound tends to separate and float on top it will adhere to the hood, and only the water will be returned to the filter. It was found that a large amount of lubricant discharging into the drain lines acts as an air-rejector, which fills the drain lines with air pockets and holds back the flow; therefore all air traps should be carefully avoided and the drain line into the filter should be located below the top level of the compound in the filtering compartment. On this class of work there is considerable advantage in using long sweep fittings or bends.

The advantages which this company secured from the installation of a cutting oil system are as follows: The record for the month of December, before the new lubricating system was installed, was 4,200,000 nuts. After the system was installed, production for the month of January was 5,300,000 nuts, or an increase in production of 25 per cent; and in February 5,500,000 nuts were produced. This increase was made with the same tools and machines and the same number of men. The non-productive work of cleaning up, etc., was eliminated, and the men who formerly did this worked on production.

In another plant where the item of tool up-keep was heavy, it was found that the tools lasted from 33 to 250 per cent longer when supplied with filtered lubricant. In still another plant, the drills had a tendency to become slightly tapered and wedge in the hole; this was found to be caused by the use of dirty cutting compound, and the trouble was eliminated when the fluid was filtered. With such tools as self-opening dies, this factory found that sediment in the cutting lubricant sometimes clogged the mechanism so that it was impossible to operate it.

# HEAT-TREATMENT OF STEEL—2[1]

PHOTOMICROGRAPH STUDY—CHANGES PRODUCED BY ANNEALING—DETERMINATION OF TEMPERATURES

BY MARTIN SYTE

HAVING observed the effect of heat-treatment on the properties of steel, in the December number, it is well to consider some of the causes underlying these results. For instance, why should the steel become hard and brittle and much stronger after hardening? Why should a hardened piece lose its strength and hardness, but gain in ductility, when reheated or drawn? In some cases these changes are very difficult to account for, as the exact cause of the hardening of steel is not known, although there are several theories. These theories will not be discussed here, but some of the points that are thoroughly understood will be considered.

If a piece of 0.10 per cent carbon steel is heated from atmospheric temperature up to about 930 degrees C. (1706 degrees F.), there will be three points at which, instead of rising, the temperature of the piece pauses or may even stop. An experiment will show that 0.25 per cent carbon steel also has three critical points. The two lower points are at practically the same temperature as those of the 0.10 per cent carbon steel, but the upper point will be at a lower temperature than the highest point of the 0.10 per cent steel. If this experiment is repeated with 0.50 per cent carbon steel, only two points will be found. The first will be at practically the same temperature as that of the 0.10 and 0.25 per cent carbon steels, but the second point will be much lower than their second point. In the case of 0.85 and 1.50 per cent carbon steels, just one point will be found, but this will coincide with the first point of the lower carbon steels.

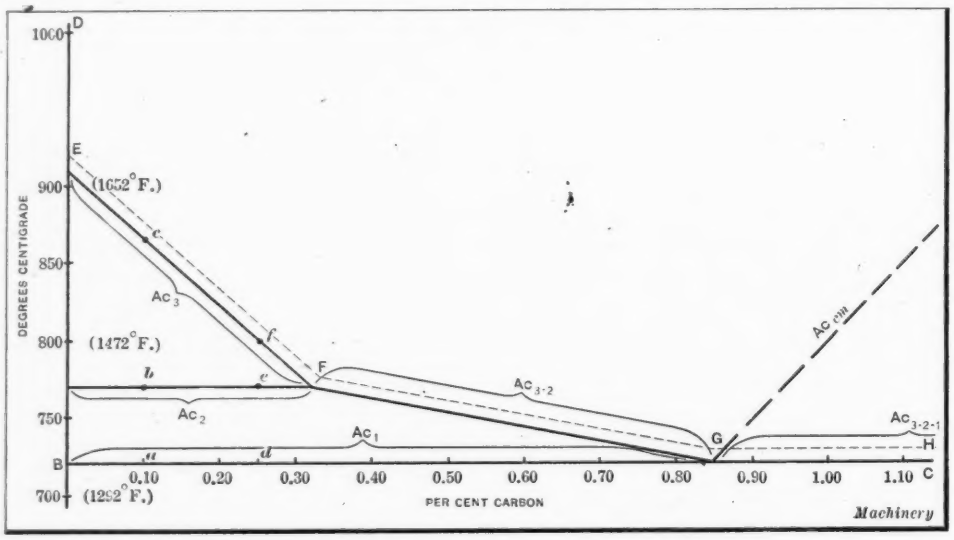



Fig. 1. Position of Critical Points in heating Straight Carbon Steel

Fig. 1 shows the location of these points graphically after a diagram by Sauveur. This diagram should be firmly fixed in mind, as it shows the relative location of the critical points of the plain carbon steels. The carbon content of the steel is shown, in per cent, along the lower horizontal line *BC* and the temperatures at which the critical point occurs along the vertical line *BD*. For instance, the points *a*, *b* and *c* are the three critical points for the 0.10 per cent carbon steel and *d*, *e* and *f* for the 0.25 per cent carbon steel. The diagram was obtained by getting the critical points of many carbon steels and then joining these points by lines.

The question naturally arises as to how these points are obtained. For instance, how is it possible to locate the three critical points of the 0.10 per cent carbon steel? There are several methods for doing this, and the ones most commonly employed in practice make use of the thermo-electric pyrometer. As it is practically impossible to use a furnace that will heat the piece at a uniform rate, it is apparent that there may be pauses or retardations in the heating or cooling that are not caused by any properties of the steel under test. In order to eliminate such pauses from the test, the temperature of the steel should be compared with the temperature of a body that has no transformation points within the temperature range covered by the experiment. If this so-called neutral body is put in the same furnace as the test piece, both bodies will be about equally affected by any irregularities in the heating of the furnace. In other words, they will be heated together, and when the temperature of one varies, the temperature of the other will vary also, so that there will never be a very marked difference in their temperatures; but when a critical point of the steel is reached, there will suddenly be a great difference in their temperatures, as the neutral body will be unaffected (possessing no critical points), while the steel will cease to rise in temperature. By using a double pyrometer to measure the difference between the two bodies, it is always possible to detect when a critical point has been reached; and a second pyrometer will show at just what temperature this point occurs. By this means the critical points of any steel can be found.

The critical points that occur in the heating of a steel also occur in the cooling, but at a lower temperature. If the point occurs in heating, it is called an *Ac* point; and in cooling, an *Ar* point. The point $Ar_1$ that occurs in cooling is called the "recalescence point," due to the fact that the steel actually gives off heat, or recalesces, at this point. Many writers use the term recalescence point very loosely, but it should be borne in mind that the only correct recalescence point is the $Ar_1$ point. The importance of knowing the location of these critical points lies in the fact that the correct hardening temperature is just above the upper critical point for any steel; or along the dotted line *EFGH*. Theoretically, it is just at the upper critical point, but it is safer to go a little higher.

### Changes that Occur at Critical Temperatures

In studying the changes that take place at the critical temperatures, the range of temperature from the lowest critical point to the highest point of any steel may be called its "critical range." If any piece of steel is heated just below the foot of the range, that is, $Ac_1$ or $Ac_{3-2-1}$, and quenched in water, it will be found that there are practically no changes in its properties. If the steel is heated to this point or a little above and then quenched, it will be found that the piece has been made stronger, harder and less ductile; that is, its tensile strength, elastic limit, and hardness have been increased while its elongation and reduction of area have been decreased. If the steel is hardened at successively higher temperatures, it will be found that it is made stronger and harder but less ductile, in each case, until the top of the critical range is reached, when the maximum degree of strength and hardness and the minimum of ductility are obtained. If the steel is heated considerably above the top of the range, there is no gain in hardness or strength; the only effect is that the grain is made coarser. In other words, steel can be hardened somewhat by heating it above its first critical point and quenching, but the full hardness or strength is not obtained until the steel is heated above the upper critical point. This fact is true of all straight carbon steels.

[1] The first installment of this article appeared in the December, 1916, number of MACHINERY.

To determine the reason for this fact, it is necessary to study the steel in the normal state. Normalized steel consists of pearlite and ferrite in the case of hypo-eutectoid steel, pearlite alone in the case of eutectoid, and pearlite and cementite in the case of hyper-eutectoid. When a piece of any of these types of steel is heated to a temperature below the first critical point, no change takes place in the microstructure, and hence there is no change in the physical properties. But if it is heated to the point $Ac_1$, there is a very marked change in the properties. This is due to the marked change in the microstructure, for just as soon as the point $Ac_1$ is passed, the pearlite, instead of remaining as a mechanical mixture of alternate layers of cementite and ferrite, becomes a solid solution. As this change of the pearlite has increased the strength of the metal, it follows that the solid solution of the pearlite constituents must be stronger than pearlite in the normalized state.

As the name implies, a solid solution has all the characteristics of a liquid as regards the intimate mingling of its constituents. In fact, in a solid solution it is impossible to distinguish, with the highest power of the microscope, one constituent from another. Hence, while before the pearlite became a solid solution, the plates of carbide (cementite) could be distinguished from those of ferrite, after it was converted into a solid solution neither could be distinguished, because they were so intimately mingled. In fact, in a solid solution each crystal contains a portion of each ingredient, and it is impossible, by any physical means, to separate the matter contained in the crystal.

As the temperature of the steel is raised above the foot of the critical range, some of the free ferrite begins to enter this solid solution and more and more of it enters the solution as the temperature is increased. In fact, when the top of the critical range is reached, all the free ferrite has entered the solid solution, and if the steel is then quenched, it will be in the strongest possible state. If the steel contained no free ferrite or free cementite, that is, if it were a eutectoid steel, all the pearlite would go into solution as soon as the foot of the range was passed (just as it did in the hypo-eutectoid steel), and the whole steel would then be in the state of a solid solution. If it were a hyper-eutectoid steel, the pearlite would go into solid solution as soon as the foot of the range, $Ac_{3-2-1}$, was crossed, but the excess cementite would not go into solid solution until the dotted line $Ac_{cm}$ was reached.

To summarize, no matter whether the steel is hypo-eutectoid, eutectoid or hyper-eutectoid, when heated the pearlite goes into solid solution at the foot of the range, $Ac_1$ or $Ac_{3-2-1}$. If there is any free constituent, as ferrite or cementite, it will be gradually absorbed into the solid solution as the steel is heated to the top of the range ($Ac_3$ or $Ac_{3-2-1}$ in the case of hypo-eutectoid steel; $Ac_{3-2-1}$, which is both top and bottom of range, for eutectoid steel; and $Ac_{cm}$ for hyper-eutectoid steel), and by the time the top of this range is reached, all the pearlite will be absorbed. In other words, no matter what kind of steel we have, it will be in the state of a solid solution as soon as it is heated to the top of its critical range.

If the steel is quenched or cooled with extreme rapidity, it will be retained, or locked, in this state, so that when it is cold it is still a solid solution; it is then called austenite. But in practice it is impossible, as a rule, to quench or cool the steel quickly enough to retain it in this perfect solid-solution state, and some of the constituents separate out of this solid solution. If the steel is cooled in liquid air, which is very cold, perfect austenite may be obtained in some cases. If the steel is cooled in water, such a close approximation to the solid solution cannot be obtained, and if cooled in kerosene, the approximation will be found to be even more imperfect. With heavy oil or air cooling, a still more imperfect solid solution is obtained.

By looking at a specimen of hardened steel under the microscope, it is possible to determine just how close it is to the solid solution. The perfect solid solution is called austenite, the first stage in its decomposition is martensite, then come troostite, sorbite, and pearlite. Each of these states has its characteristic appearance under the microscope.

It has been shown that by heating steel to the top of its critical range the steel is put in the solid-solution state, and by quenching in mediums of varying effectiveness the steel may be obtained in the cold state as a solid solution, or one of its decomposition products. But it is possible to obtain the exact decomposition product desired by heating to the top of the range, cooling rapidly enough to get austenite or martensite, and then reheating below the range so as to get troostite or sorbite. In other words, it is possible to obtain the steel in the exact state desired by simply hardening it with the proper rapidity, or by hardening and then reheating or drawing the steel. The hardening process converts the steel into a fine-grained solid solution (or to an approximation), and the drawing treatment lets the steel decompose into one of the states that experience has shown is best suited for the work desired.

In the specimens used for determining the chart shown in Fig. 1, the steel was first hardened just above the top of the critical range, which was determined by means of a neutral body and pyrometers. After this steel was hardened it was as close to a solid solution as it was desirable to get this particular steel commercially; it was then in the state of martensite. Some pieces were then drawn at each of the temperatures shown on the chart, and the martensite was decomposed by this drawing into the softer and weaker, but more ductile, decomposition products, troostite and sorbite. It should be mentioned that each of the successive decomposition products of austenite is softer than those preceding it, except martensite, which is harder than austenite.

### Changes Produced by Annealing Process

In a good many cases where steel is to be annealed, the only object desired is to soften the steel so that it can be machined or worked more easily. In other cases, it is desirable not only to make the steel softer, but also to refine the grain size and to make the steel soft. In order to anneal steel perfectly for the latter purpose, it should be heated to the top of the critical range, held there until every part has been thoroughly heated to this temperature, and then very slowly cooled, preferably in the furnace. This will not only wipe out any coarse structure and make the steel fine grained, but it will leave the steel as soft as possible. This is due to the fact that when the steel is heated to the top of the critical range, it goes into the state of a fine-grained solid solution. Then by slow cooling the steel is given no chance to set in this solid-solution state, but forms soft, ductile sorbite or pearlite. If the steel is cooled more rapidly, it will not be given sufficient time to decompose from the solid-solution state, and troostite or sorbite, or a combination, is obtained. If the steel is cooled in the air, it will be still harder, due to the fact that cooling in air is a sort of mild form of hardening. This is shown very clearly in Fig. 1, where the steel has been hardened, then reheated to the top of the range and air cooled. It will be noted that both the tensile strength and the hardness are increased.

The most perfect way to anneal is to heat the steel to the top of its range and harden; this gives a fine-grain hard steel. It should then be reheated to just below the foot of the range and cooled very slowly; this gives the finest grain possible, together with extreme softness, and is a method much used in France. It has been found best to harden hyper-eutectoid steel of 0.85 per cent carbon or more just above the line $Ac_{3-2-1}$, for if the top of the range $Ac_{cm}$ is passed, all the excess cementite may be in solid solution, but this higher heat will enlarge the grain so much that the advantage gained does not pay. The one exception to this is the case of high-speed steels, which, due to their special ingredients, may be heated above $Ac_{cm}$ and all excess elements changed into solid solution, without dangerously enlarging the grain size.

The literature on hardening is sometimes very inexact and unclear, but if it is remembered that the line *EFGH* shows the proper point for hardening, no confusion should result. In all cases the hardening or correct annealing temperature is the top of the range $Ac_3$ or $Ac_{3-2}$ in steel under eutectoid carbon content, and $Ac_{3-2-1}$ on all eutectoid and hyper-eutectoid steels with the exception of high-speed tool steels.

### A Typical Heating Trouble

In considering the practical operations of hardening, it will be found that the theoretical knowledge gained will stand us in good stead. We may harden a brand of steel for months with complete success and then suddenly have trouble at some inopportune time. The steel may not harden the way it did before, or it may crack in the hardening. The exact cause is sometimes difficult to find, and the man whose practical knowledge is not coupled with an understanding of the why and wherefore of his hardening operations frequently finds himself in trouble.

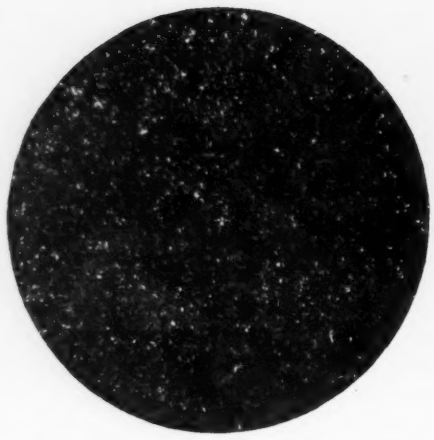


Fig. 2. Photomicrograph of Steel correctly hardened

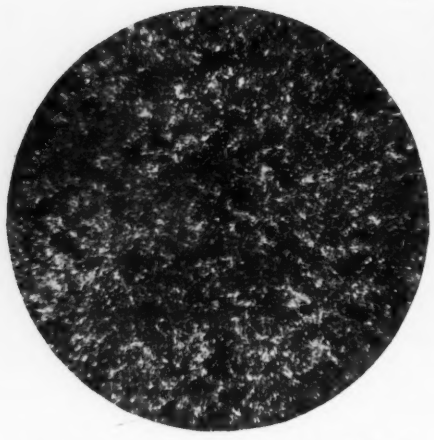


Fig. 3. Steel shown in Fig. 2 magnified to 400 Diameters

For instance, a hardener had been getting entirely satisfactory results by hardening arbors in oil. He had hardened thousands of them without experiencing any trouble when suddenly they tested soft after the heat-treatment. The hardener was the center of all the resulting complaints, and naturally he claimed that the analysis of the steel was different from what he had been getting. By using water instead of oil and heating considerably higher, he managed to make a fairly satisfactory job, but still a considerable number cracked in the hardening. The steel manufacturer insisted that the steel was within specifications, and actually showed by analysis that the former pieces that hardened in oil and those which required water quenching were the same steel. The hardener, who merely did this work by rule, was naturally at a loss to overcome this trouble and eventually lost his position. Investigation later showed that the steel in both cases was identical, but that the supplier, having run short of the size bar generally supplied, had obtained permission to supply a smaller one. As very little stock was turned off from this, the decarburized outer skin, or bark, was not completely removed. Therefore, instead of the steel being 0.65 per cent carbon, as specified, the exterior was 0.35 per cent carbon and the interior was 0.65 per cent. It therefore required water and a higher heat to make this low-carbon outside portion hard enough.

If the hardener had only studied the theory a little, he would have known that this higher heat and water quenching was an indication that the carbon was lower. His limited general knowledge kept him from knowing that his first contention that the analysis varied was correct, as far as the outer surface of the bar was concerned, and that the steel manufacturer was also correct as far as the analysis of the interior of the piece was concerned. The solution in this case was very simple, but the writer recalls other cases where a thorough knowledge of both the practical and theoretical side was required before the trouble could be located and remedied.

### Determining Proper Heat-treatment Temperatures

We should keep in touch with the theory as much as possible, even while describing briefly some of the practical points to be observed in the heat-treating of steel. Let us suppose, for instance, that a new type of steel is to be hardened. If the analysis were known, it would help very much in estimating the correct hardening temperature, but it will be assumed that this is not known. If a critical-point outfit can be obtained, the critical points of the steel can be determined; then the critical temperature diagram, Fig. 1, will help us tell the correct temperature to use.

If an outfit of this nature is not at hand, samples of this steel, all cut to approximately the same size and shape, should be hardened in water at different temperatures, starting at 732 degrees C. (1350 degrees F.) and increasing the temperature 15 degrees C. for each sample. The test pieces should then be broken by the same method so that the fractures will be comparative. All soft pieces may be disregarded and only the harder ones examined. Those with the finest grain may be separated from the others and should then be tested to ascertain which is the hardest. Nearly all shops possess either a scleroscope or Brinell hardness tester, but if these are lacking, a file may be used, although in this case it is a poor substitute.

It will probably happen that several pieces will look almost alike as far as grain size goes; in this case the hardest piece will represent the nearest approach to the correct hardening temperature. In other words, the piece that combines the finest grain with the greatest hardness is the one most perfectly hardened. If desired, when the temperature at which this piece was heat-treated has been noted, the test may be repeated by hardening, say, four more pieces at intervals of 5 degrees C. above and below the hardening temperature of the piece chosen by inspection. These pieces should be broken and tested as before, and the one showing the finest grain with the greatest hardness will represent the correct hardening treatment. The second experiment is performed only to locate the temperature a little more accurately than in the first experiment, where 15-degree intervals were used.

If the steel does not show any material increase in hardness at any of the temperatures tried, it is probably a low-carbon steel which, due to its carbon content, cannot be materially hardened. In this case, a file will not do for the hardness test, so a more delicate instrument must be used.

In many cases it will not be necessary to undertake the above experiment, as the manufacturer supplies the information regarding the hardening treatment. Where the chemical analysis is given, by referring to Fig. 1 the hardening temperature may be quite accurately estimated and a trial may be made to confirm it.

Fig. 4. Cast Steel before it is rolled or heat-treated

If the steel is an alloy steel, it must be borne in mind that in addition to the carbon content the special alloying element may influence the correct hardening temperature; for instance, nickel lowers the hardening point about 20 degrees C. for every per cent of nickel in low-carbon steels containing less than 5 per cent nickel; manganese also lowers it. Vanadium, chromium, and silicon have no marked effect.

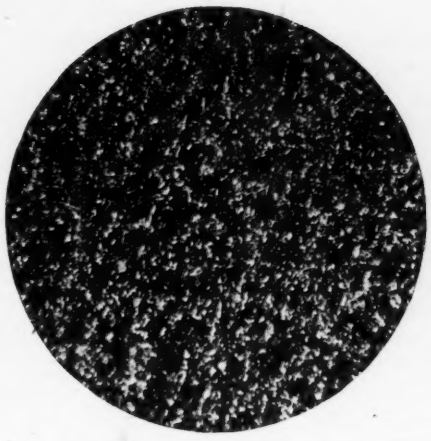


Fig. 5. Steel shown in Fig. 2, hardened at too Low a Temperature

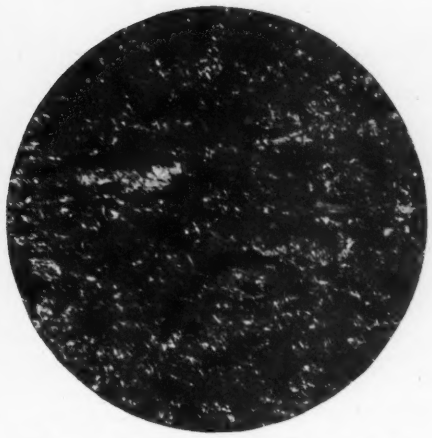


Fig. 6. Steel shown in Fig. 2, when it has been overheated

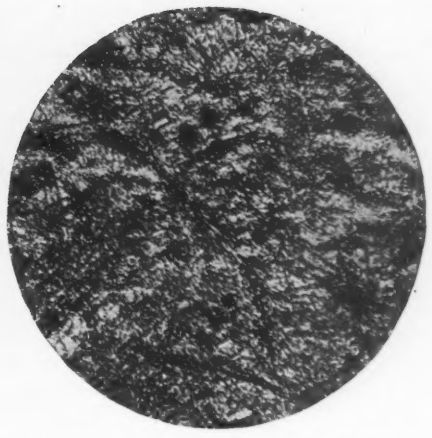


Fig. 7. Steel shown in Fig. 2, when it has been burned

Before proceeding further, we should understand what happened to the steel that was tested for its hardening temperature. Let it be assumed that it was about 0.50 per cent carbon steel. All the test pieces that were heated up to a point below $Ac_1$, Fig. 1, remained soft on quenching. The first piece heated above $Ac_1$ and quenched showed an increase in hardness because the pearlite grains had been transformed into austenite and the quenching served to lock them, if not in this state, in an approximation to it which should be hard. As the different pieces were heated to successively higher temperatures through the range, more and more of the excess ferrite entered into the solid solution of austenite, so each of these successive pieces when quenched, therefore, was harder than the previous one. When those pieces that had been heated above the top of the range, where they are converted completely into a solid solution, were quenched, a maximum hardness was obtained. If these pieces were heated much farther above the top of the range and quenched, there would be no gain in hardness; rather the steel would be overheated, which results in a large grain size as already mentioned.

### Photomicrographs of Good and Defective Steels

Fig. 2 is a photomicrograph showing the fine grain resulting from hardening a steel at the correct temperature. Fig. 3 shows the same steel magnified still more—to 400 diameters; yet it still appears very fine grained. The actual diameter of the spot of steel shown in Fig. 3 is only 0.008 inch; thus it will be seen that this photomicrograph shows a part of the steel about as big as a pin point. Fig. 4 shows a photomicrograph, of 100 diameters magnification, of cast steel before it was refined by the rolling process and by heat-treatment. The enormous difference in the grain size is apparent and serves to illustrate what changes can be wrought in steel by the correct treatment.

Fig. 5 shows a piece of the same steel as that shown in Fig. 2, which has been hardened at too low a temperature. The steel shown in Fig. 2 had a Brinell hardness of 578, while that shown in Fig. 5 had a Brinell hardness of only 248. To the eye the fracture of both might appear about the same, but the hardness test shows that the second one has not been heated to the top of the range, because it does not possess its maximum hardness. Fig. 6 is a photomicrograph of the same steel when it has been overheated; that is, heated above the top of the critical range farther than is necessary. It shows a coarser grain size, yet it is no harder than the steel shown in Fig. 2. Nothing has been gained, therefore, by overheating; in fact, the coarser grain size is a distinct disadvantage, because the metal is weaker and more brittle. Fig. 7 shows the same steel heated to a temperature of 1000 degrees C. (1832 degrees F.), which is so much too high that it has resulted in burning the metal at some points. This is shown more clearly in the higher magnification, Fig. 8. These illustrations show the importance of finding the correct hardening temperature. If the steel is heated below this temperature to harden, the maximum hardness or strength is not obtained; if it is heated too far above this temperature, it is coarsened and its physical properties are impaired; and if the heating is carried still farther, the steel may be ruined by being burned.

If the steel with a very coarse grain, as shown in Fig. 6, is not heated to the top of its critical range, this coarse grain will not be entirely eliminated; but if it is heated to the top of the range and quenched, the coarse grain will be refined, unless it has been badly overheated and burned. Fig. 9 shows the same piece of steel as that in Fig. 6 after it has been refined by heating to the correct temperature.

However, if the steel has been previously burned or abused, it may be impossible to restore it to a fine-grained and strong state. For instance, unless the steel is remelted, no amount of heating can repair the cracks produced in the burned steel of Fig. 8. Fig. 10 also shows a case where no hardening temperature can bring the steel into a state of proper hardness, for the edges have been very badly decarburized by the steel mill. This is shown by the fact that the edge *A* appears lighter than the inner part *B*, because the former has less carbon bearing or pearlite grains.

It must be borne in mind that the temperatures given in the accompanying table are not to be arbitrarily followed, because other constituents in the steel, such as manganese, affect the correct hardening temperature. They are given to aid the beginner, so that he will know approximately where to start his test for the correct hardening temperature, if he knows the analysis of the steel. It is only possible to obtain the exact temperature by experience.

In practice, after the theoretically correct hardening temperature for a given steel has been obtained, it is advisable to heat slightly above this temperature to allow for any delay in getting the steel into the quenching bath or any other cause that might possibly allow the temperature of the

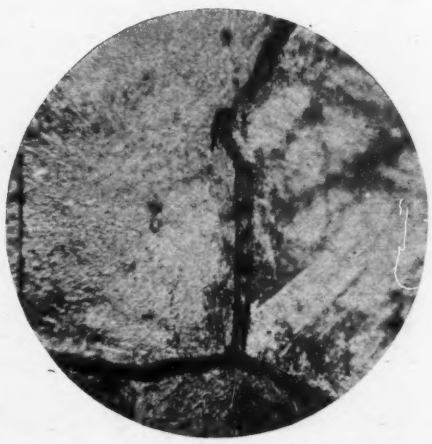


Fig. 8. Higher Magnification of Steel shown in Fig. 7

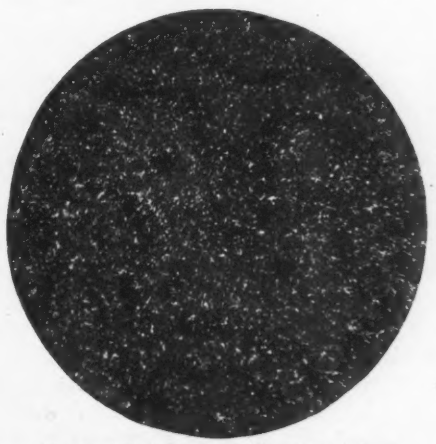


Fig. 9. Steel shown in Fig. 6 heated at Correct Temperature

APPROXIMATE TEMPERATURES FOR HARDENING CARBON STEELS

| Carbon, Per Cent | Hardening Temperature | |
|---|---|---|
| | Degrees C. | Degrees F. |
| 0.10 | 885 | 1627 |
| 0.20 | 865 | 1589 |
| 0.30 | 845 | 1553 |
| 0.40 | 825 | 1517 |
| 0.50 | 805 | 1481 |
| 0.60 | 790 | 1454 |
| 0.70 | 780 | 1436 |
| 0.80 | 770 | 1418 |
| 0.90 | 760 | 1400 |
| 1.00 to 2.00 | 760 | 1400 |

*Machinery*

steel to drop below the top of the critical range. If it drops one degree below this temperature, the piece will not possess the maximum hardness, while if it is heated ten degrees above the top of the range and the temperature should fall one or two degrees before the piece is in the quenching bath, the steel will still be above the top of its range and will not lose any of its hardness.

The alloy steels, especially those containing chromium, can be heated farther above the top of their critical range without impairing their physical properties by enlarging the grain than can the plain carbon steels. This fact should not be taken advantage of to "take chances" in the treatment, but should be considered as merely a point in their favor toward obtaining quality.

### Time Necessary for Heat-treatment

The next point to be considered is the time required to heat the piece to the correct temperature and the length of time it should be held at this temperature. Generally, the rate of heating a piece to the hardening temperature is given very little attention. The excellent alloy steels of today can be heated quite rapidly without impairing their quality to a marked extent, and this fact is taken advantage of in commercial hardening on a large scale. It must always be borne in mind that when trouble does occur this point should be investigated, for too rapid heating may result in cracking the steel and impairing its qualities. This is especially true in the case of cheap grades of steel that have been hardened and are being rehardened without first being annealed or carefully preheated.

No fixed rule can be given for the rate of heating, as this point can be determined only by intelligent experience. When the piece has been heated to the proper temperature, it should be held at this temperature until sufficient time has been allowed for the complete grain transformation to take place throughout the whole piece. It was believed for some time that when the outside of the piece was of the correct temperature the interior portions were still much below this temperature, but recent experiments have shown that the interior temperature of the piece lags only a very little behind the exterior temperature. This must not be construed as a reason for not giving the piece time to "saturate," for this time must be allowed; its purpose is to give time for changes to be completed in the structure of the steel rather than to effect a complete temperature saturation of the whole piece.

A point of great practical importance and one that must not be overlooked in discussing the heating of the steel for hardening is the pyrometer and its location. A great many hardening furnaces have different temperatures at different parts of their heating ovens. The writer has observed cases where the pyrometer was in the rear of the furnace and read 1420 degrees F. At the same time a piece located near the pyrometer was at a temperature of 1400 degrees F., while a piece in the front of the furnace was at a temperature of only 1380 degrees F. When quenched, a marked variation in the hardness of the two pieces was naturally noted. Wherever possible, the pyrometer should be as close to the piece being hardened as possible. If it is impossible to realize this condition, the hardener should make tests so as to know just what discrepancy exists between the temperature of the pyrometer and the piece; in other words, he should know the temperature conditions that exist in the furnace, so that even if they cannot be corrected they can be intelligently allowed for.

All pyrometer connections must be kept tight and clean and should be soldered wherever practicable. The pyrometer should be checked frequently with a master outfit kept solely for this purpose.

### Quenching Mediums

Water quenching gives greater hardness than oil, and cold water and cold brine give still greater hardness. In choosing the quenching medium, we are therefore governed chiefly by the hardness desired and the amount of drastic quenching that the steel will withstand without cracking or severe distortion. A good many concerns use steels entirely unsuited for the purpose intended, and get the necessary hardness by what might be termed "forcing"; that is, the steel is quenched in a very drastic medium, such as ice-cold water, which often results in cracking the steel. By using a better grade of steel or a steel of higher carbon content and quenching it less severely, as, for instance, in oil, the necessary hardness or strength may be obtained with a larger factor of safety against cracking and distortion of the steel. Some steels, however, are made to harden in water and others in oil, and the manufacturers of these steels give instructions to this effect. In the absence of definite information, the beginner can best determine this point for himself.

By removing the steel from the quenching bath before it has become entirely cold, the danger of cracking is greatly reduced, for this allows the steel to be slightly tempered. In some cases, excellent results may be obtained with steel that will crack if quenched entirely in water by placing it in water for a few moments and then removing it quickly and plunging it in oil, where the quenching may be completed. The length of time the work should be held in the water can only be determined by actual trial. Generally, it may be held there until the vibration felt along the handles of the "pick-up" tongs, due to the violent formation of steam around the piece, has almost or entirely ceased.

A very important point in quenching steel is to get the work into the bath as quickly as possible. Just as soon as the furnace door is opened, the inrushing air strikes the piece to be hardened and chills it. As the piece is removed from the furnace, this chilling effect becomes more pronounced. If the piece is one of complicated section, the smaller parts and edges may be materially affected. For this reason, the quenching bath should be located in the most advantageous spot for rapid work.

### Pack-hardening and Tempering

Pack-hardening must not be confused with casehardening, where the work is also packed. In casehardening, the object of the packing is to give a pronounced case to certain portions of the steel; while in pack-hardening, the object is to

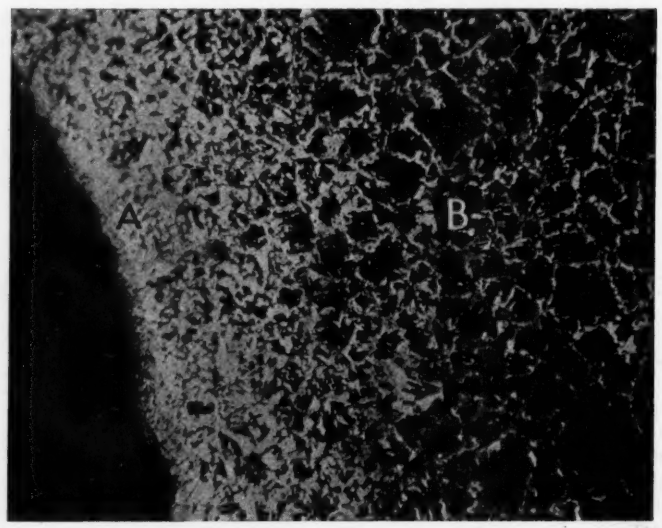



Fig. 10. Steel badly decarburized at Steel Mill

heat the piece through thoroughly and to prevent the scaling or oxidation of the surface that will result, to a more or less extent, if the piece is heated in the open fire. The parts to be heated, therefore, are packed in metal pots or boxes with charcoal, or some other material that will not have a decarburizing effect upon the steel. The pots are then heated through at the proscribed temperature and held at this heat for the proper length of time, after which the pieces are removed and quenched.

It is very important to know just what temperature exists within the pots and how long they require to become heated through. Preliminary tests should be run with pyrometer ends inserted within the pots and enough data obtained so that an accurate idea exists as to how long each size pot should be heated with a given size load of steel within it. The old method of running wires, through holes drilled in the pot cover, into the interior contents of the pot and withdrawing a wire at given intervals of time and noting its color as compared with that of the furnace walls may also be of value.

The proper tempering, or drawing temperature, as it is also called, depends on the use for which the steel is intended. If it must be intensely hard, it should be drawn, or tempered, at a very low temperature, or the operation may be omitted altogether. If a certain amount of toughness or ductility is desired, the steel must be tempered, unless it is a steel of such analysis, for instance a low-carbon steel, that it possesses enough ductility after being hardened only. Fig. 1 shows that, as we draw or temper a hardened steel, the solid solution (or its approximate state) is decomposed and constituents are formed that make the steel weaker and softer, but more ductile.

By tempering a straight carbon steel at about 400 degrees C. (752 degrees F.) it is changed into the troostitic state, unless it is a steel of such nature, or is hardened in such a way, that it contains some still lower constituent, even after hardening, such as sorbite. Troostite is much softer and less brittle than martensite, and is usually the most common constituent found in commercially hardened and tempered steels. By tempering at 600 degrees C. (1112 degrees F.), which is generally considered annealing, a sorbitic structure that is still more soft and ductile than troostite is obtained.

After a steel has been correctly hardened, it should be drawn, experimentally, at different temperatures and tested to find out how it stands up for the particular application intended. Experience has shown the degree of heat required for tempering for quite a variety of purposes, and these temperatures may be obtained in numerous books on hardening. In practice, there are several methods of tempering hardened steel. The steel may be heated to the hardening temperature. The end desired hard is then plunged into the quenching bath until it is fairly well hardened and is then withdrawn, rubbed bright, and held until the heat of the unquenched part has crept down to the hardened end and heated it to the proper temper color, when the whole piece is plunged into the bath and quenched. In the hands of a skillful and experienced hardener, this method may be entirely satisfactory.

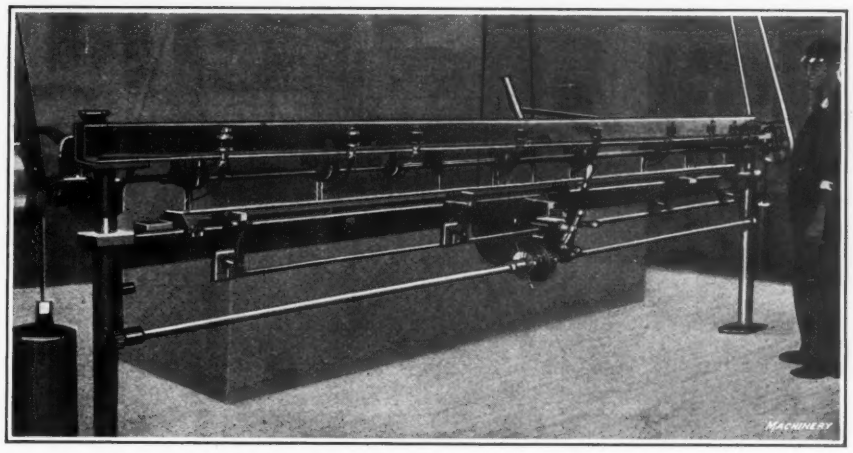
Another way of tempering is to heat the part in a bath of hot oil. Oil can be obtained that will stand a temperature of about 343 degrees C. (650 degrees F.). This is a very accurate way, as the exact temperature of the oil may be obtained by a thermometer and the piece is certain to be tempered uniformly all over. For temperatures between 260 to 583 degrees C. (500 to 1100 degrees F.) a bath composed of equal parts of potassium nitrate and sodium nitrate may be used. Lead and sand baths are also employed for tempering. In every case, however, the same object is accomplished. The solid solution (austenite) or its approximation (martensite or even troostite) formed in hardening is decomposed into a lower constituent or lower combinations, such as martenso-troostite, troostite, troostito-sorbite, or sorbite itself. All of these have more ductility and less hardness than the constituents above them.

Some of the main factors in heat-treating steel and the underlying theory have now been considered. While it has not been possible to give exhaustive attention to every point, an effort has been made to show that there is a reason for each process and also what that reason is. Much progress remains to be made in the investigation of some of the causes of the changes observed in heat-treatment, but if each hardener will study the subject intelligently and forget the rule of thumb or the mysterious formula lent him by some kind acquaintance, he will soon acquire a knowledge that will help him to overcome obstacles and place his work upon a successful scientific basis.

* * *

## SPECIAL DRILLING MACHINE FOR T-SECTIONS

The work for which the special drilling machine shown in the accompanying illustration was designed is the drilling of 1¼-inch T-sections, approximately 15 feet long. The largest drill used in this machine is 3/32 inch. Twenty holes can be drilled at one time, and the extreme center distance between the end drills is 14 feet. The two outer sets of 3/32-inch holes are approximately 6 inches from the ends of the work, and there are about ten additional sets of spindles carrying 3/32-inch drills placed at various distances between. The power is transmitted to the two sets of vertical drill spindles by two parallel horizontal shafts, one of which is driven by a flat belt at one end of the machine and the other by a similar belt at the other end. This does away with the use of gears, which are necessary with but one driving pulley. All the drill heads are adjustable longitudinally. The power feed for the table is accomplished through the medium of a round belt in the middle of the machine which runs on a wooden pulley from the line-shaft above. The work-holding clamps bear at several points along the length of the work; yet they are all operated from one position.



Special Drilling Machine for T-sections

One operator can drill these 15-foot T-sections at the rate of fifty per hour, or 900 3/32-inch holes per hour. Each drill is lubricated by an individual oil-cup located at each spindle. The oil feed is positive, so that the operator does not need to pay attention to the matter of lubrication.

The machine was built by the Sellew Machine Tool Co., Pawtucket, R. I., for Cuddy-Gardner Co., Providence, R. I., maker of carpet display racks, of which these T-sections are a part. Though the machine is of skeleton construction, it is sufficiently rigid for the work it is called on to do. V. B.

* * *

The largest and latest Zeppelins, one of which, the L-33, was brought down near London, are 680 feet long and, with their crew of twenty-two officers and men, are estimated to weigh 50 tons. They carry four gondolas, in which are mounted six Mercedes engines, each of 240 horsepower, and can carry about 2000 gallons of gasoline in their tanks. They are armed with seven guns.

# MULTIPLE TOOLS FOR THE LATHE

## TURNING TOOLS THAT SAVE LABOR AND FACILITATE PRODUCTION

BY HENRY M. WOOD[1]

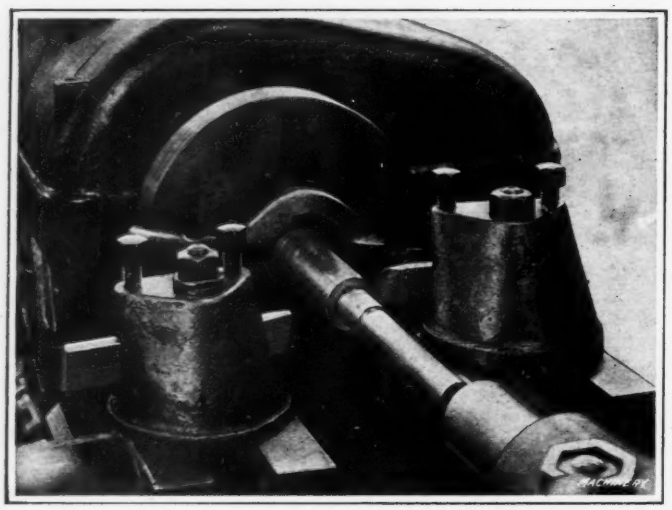


Fig. 1. Shaft Turning with Connected Compound and Plain Rests

IN chucking operations, it is common shop practice, whenever the nature of the work permits, to bore with a tool held in the turret on the bed at the same time that a turning cut is being taken with the carriage tool. Such use of multiple cutting tools is generally understood; therefore, although turret operations are strictly instances of the use of multiple cutting tools, this article will be confined to jobs turned between centers or on arbors where multiple tooling is not so generally used.

A large variety of lathe work requires the use of different tools, but the work is of such a nature that two or more tools cannot be cutting simultaneously. This class of work is handled in one of the following ways:

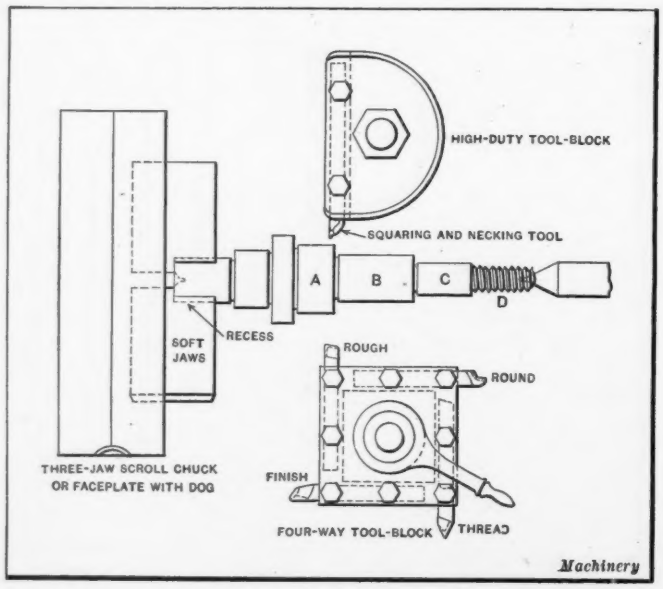



Fig. 2. Lathe Set-up for Operations requiring Five Tools

1. By changing tools in the toolpost. In this case, an engine lathe with one holder for a single tool is used. The piece is kept between centers until it is finished and the tool is changed as often as necessary. For example, after rough-turning, the turning tool is replaced by a squaring and necking tool, a chasing tool, etc. Under this method considerable time is lost by stopping the lathe and changing tools.

2. By changing work for separate operations. The first operation, probably rough-turning, is performed on an entire lot of parts; then the tool is changed and the shoulders are squared and necked (if that is the second operation) on every piece in the lot. Additional tools, if necessary, are used for subsequent operations. This method is usually preferable to the first, because in the case of light shafts or studs, which is the usual class of work turned between centers, the work can be changed more quickly than the tool.

3. By using a front tool for turning and a rear tool for squaring and necking. These tools do not both cut at the same time, but they perform both operations without either the tools or the work having to be changed. Fig. 1 illustrates such a job. The shaft being turned is a typical example of lathe work having different diameters and shoulders. The front tool on the compound rest does the turning. As soon as one of the shoulder positions is reached the rear tool on the plain rest is moved forward to square the shoulder and to neck, at that point, a little below the diameter which has just been turned, to give clearance for the wheel on the last operation of grinding. The compound and plain rests are connected, so that one movement of the cross-feed screw withdraws the front tool and advances the rear tool for performing the squaring operation.

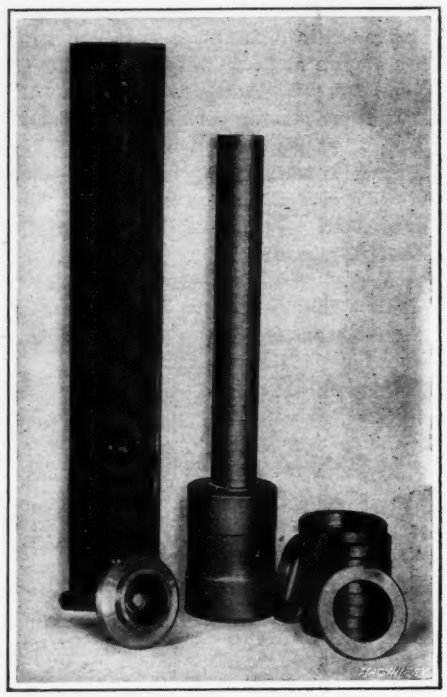


Fig. 3. Special Nuts and Stock from which they are turned

This method is applicable where not more than one turning tool and one squaring tool are required. It saves all the time which, under the former methods, was lost in stopping the lathe to change the tools or work. This equipment is made still more efficient by the addition of multiple stops for length-feed and cross-feed, which locate the carriage and cross-slide positions for both lengths and diameters. As a result, it is not necessary to stop to make any measurements after the stops have been properly set for the first piece of a lot. To obtain a comparison, ten driving shafts, like that shown in

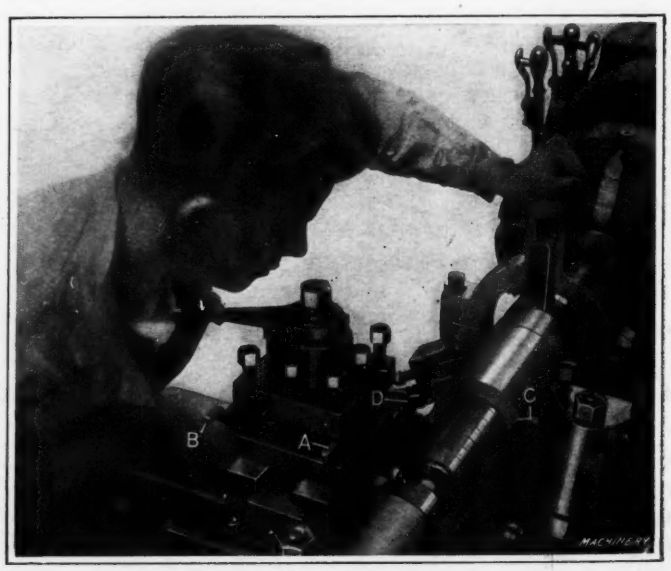



Fig. 4. Facing End of Bar after boring out Nut

[1] Address: Lodge & Shipley Machine Tool Co., Cincinnati, Ohio.

Fig. 1, were turned with this equipment in one hour, fifty-six minutes. Then the same operator turned ten shafts in the same lathe, but without the connected rear rest or the multiple stops; the time required was four hours, three minutes. The turning tool has a straight-line cutting edge, which is

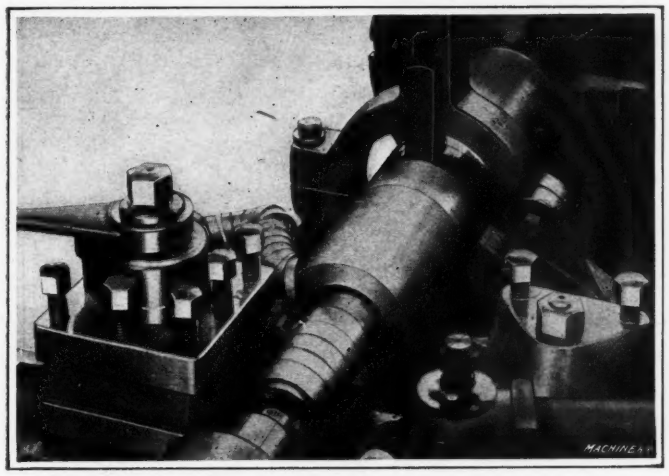


Fig. 5. Boring out Nut

set at right angles to the axis of the work, and a round nose of comparatively small radius of curvature. This leaves a minimum amount of stock to be removed by the squaring and necking tool.

4. By using a four-way (turret) tool-block for turning, rounding, and threading tools in the compound rest; and a single tool-holder for the necking tool in the connected rear plain rest. This equipment is used where one turning tool and one necking tool are not enough for the different operations required on a piece. Fig. 2 is a tooling diagram, in plan view, of a typical lay-out of this sort. If the work is complicated and requires more than five tools, four-way tool-blocks may be used on both the front and the rear rests.

The four-way tool-block made by the Lodge & Shipley Machine Tool Co. fits into the regular T-slot of the compound rest or rear connected plain rest in place of the single high-duty or round toolpost. From one to four tools can be rigidly held in the four-way tool-block, and it can be quickly indexed to

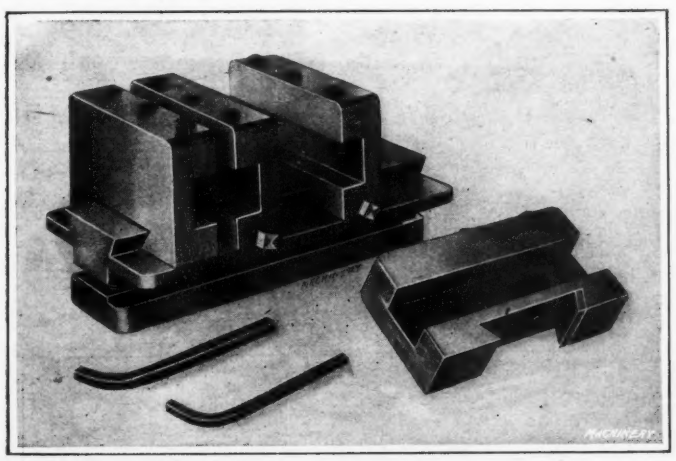


Fig. 6. Gang Tool-block with Adjustable Holders

bring any one of the tools into the working position. Its advantages over the older turret toolpost are that it may be quickly put on or taken off without disturbing the regular compound rest, and also that the angular feed of the compound rest is available for use with any one of the tools. The job illustrated in Figs. 18, 19, and 20 could not be handled in this way with a plain turret toolpost. The four-way tool-block, connected compound and plain rests, multiple stops, pan, pump and tubing form the "manufacturing equipment," and added to the engine lathe make it an efficient machine for rapidly and accurately turning duplicate parts. All the necessary tools are carried on the lathe ready for use in quick succession, and the diameters and shoulders are determined without stopping the lathe.

### Manufacturing a Thin Nut

An interesting example of lathe work, which also illustrates the application of the manufacturing lathe just described, is turning washers, collars and thin nuts from bar stock. Fig. 3 shows various stages of the lathe work; the rough stock is shown at the left, the stock after a number of nuts have been turned from it in the center, some of the nuts, which are threaded on the outside, at the right. Instead of cutting the center of the original stock into chips, a core is left nearly as large in external diameter as the hole through the nut. This is not only a saving in material, but also in time, because much less weight of material must be cut up into chips. The tool equipment can be clearly seen by reference to Fig. 4. The sequence of operations is as follows:

1. Grip one end of rough bar stock in four-jaw chuck, and support other end by tailstock center.

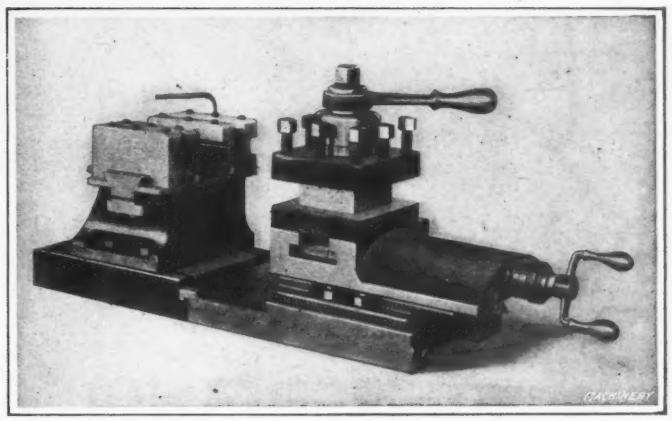


Fig. 7. Connected Compound and Plain Rests with Four-way and Gang Tool-blocks

2. Use turning tool in four-way tool-block on compound rest. Set to proper diameter by cross-feed stop. Turn outside diameter up to chuck jaws. The turning tool is not shown in Fig. 4, as it is on the far side of the four-way tool-block.

3. Adjust steadyrest. Index to next diameter stop, which has been set for full depth of thread. Index four-way tool-block to bring chasing tool *A* into position. Chase thread on outside diameter for a length of about twelve inches, making final cut to proper depth as determined by diameter stop.

4. Start at tailstock end of work, index to next diameter stop, and revolve four-way tool-block so as to use the hooked boring tool *B*. Set to diameter stop and bore to depth a little greater than thickness of one nut, up to length-feed stop. This is the operation illustrated in Fig. 5.

5. Face end, as in Fig. 4, using facing tool *C* in rear connected plain rest. The correct carriage position is determined by length-feed stop.

6. With cutting-off tool *D* in four-way tool-block feed straight in for a depth of about ⅛ inch. Length-feed stop locates carriage to give correct thickness of nut.

7. Turn back to chasing tool *A* and use it to bevel sides of cut that has just been started.

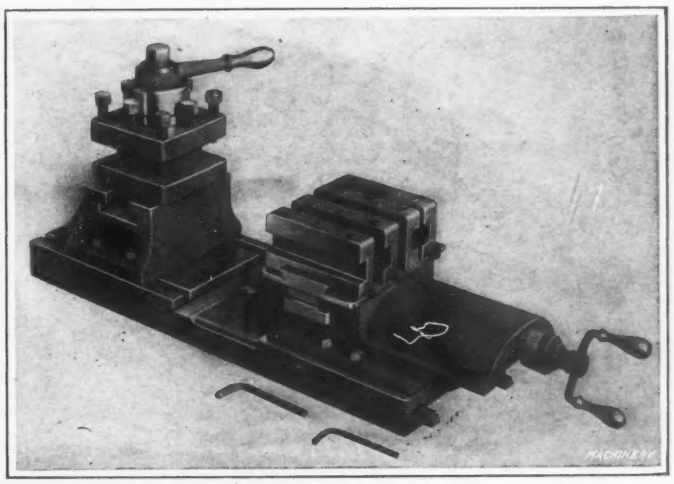


Fig. 8. Same Equipment as in Fig. 7, but with Tool-blocks interchanged

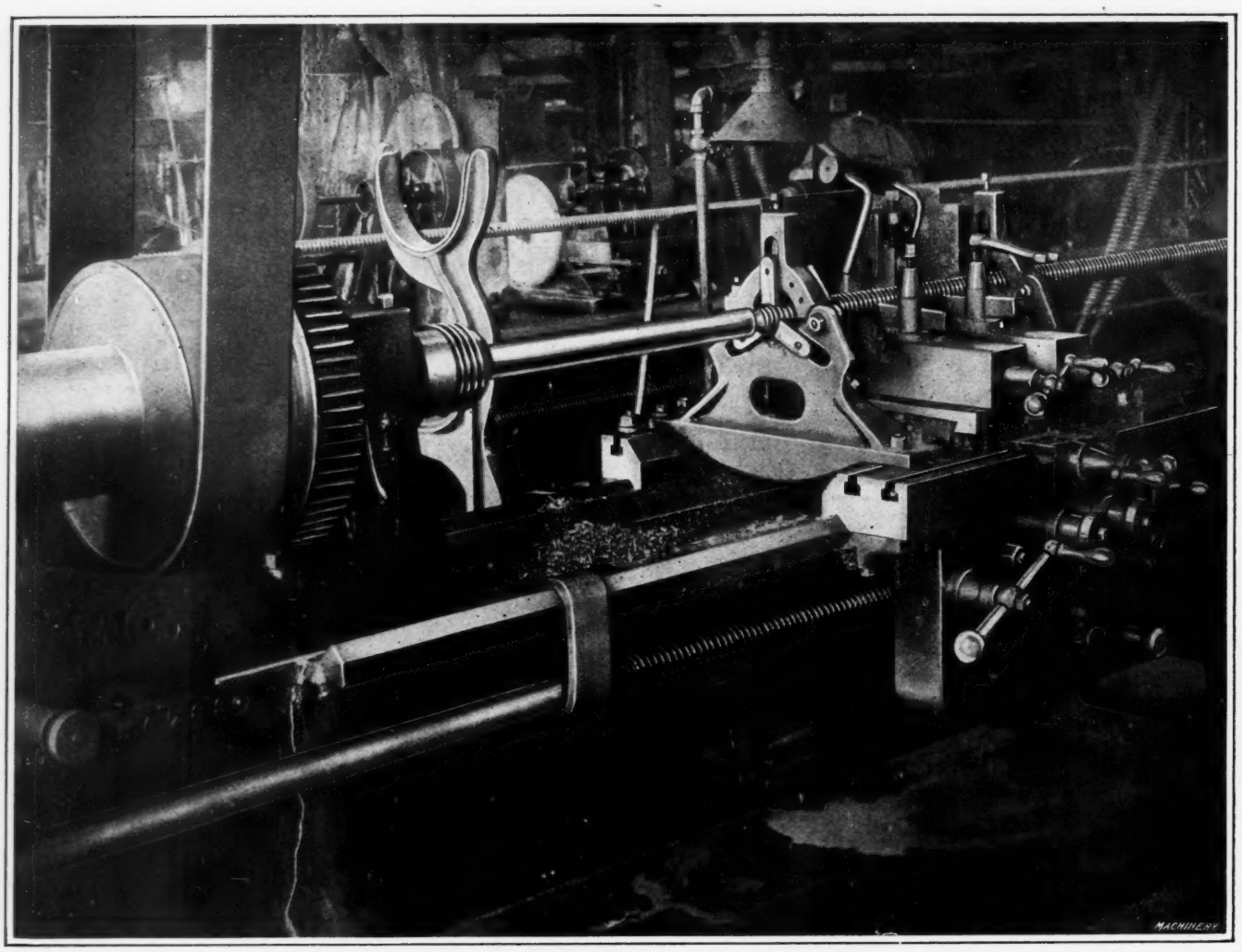


Fig. 9. Chasing Precision Screw in a Lathe with Two Tools

8. Re-index four-way tool-block to cutting-off tool *D* and finish cutting off nut.

For the next nut, start with the fourth operation, and repeat the fifth, sixth, seventh and eighth.

### Gang Tools

Frequently, work is of such a nature that multiple tool equipment can be used with several tools cutting simultaneously. The individual tools are held either in adjustable holders or in a fixed block. Among the different ways in which gang tools are used, the following may be mentioned:

1. Dividing a heavy roughing cut between front and rear tools, when turning a rough forging.

2. Roughing with one or two front tools and finishing with a rear tool at one pass of the carriage, as in shaft turning.

3. Turning different diameters simultaneously by several tools arranged in a gang and set at proper distances from each other and from the center of the lathe.

4. Turning the same diameter with two or more tools cutting at different places on the work, so as to reduce the length of carriage travel. For example, if the piece to be turned measures six inches between shoulders, it can be produced with a carriage travel of three inches if two tools are used in a gang, one starting at the center and the other at the end.

5. A combination of the last two methods.

6. Forming, by feeding tools straight in with cross-feed.

The time required for setting up a gang of tools is longer than for single tools. If the piece is slender, gang tools must be ground more frequently than single tools and a somewhat finer feed used to avoid springing the work. For these reasons, it is by no means advisable to use the gang method wherever it will show merely a lower cutting time per piece than the single tool. However, gang tooling is extensively used, and with much success, by a few of the large manufacturers of duplicate parts, and can be profitably extended to quite a variety of work in other shops.

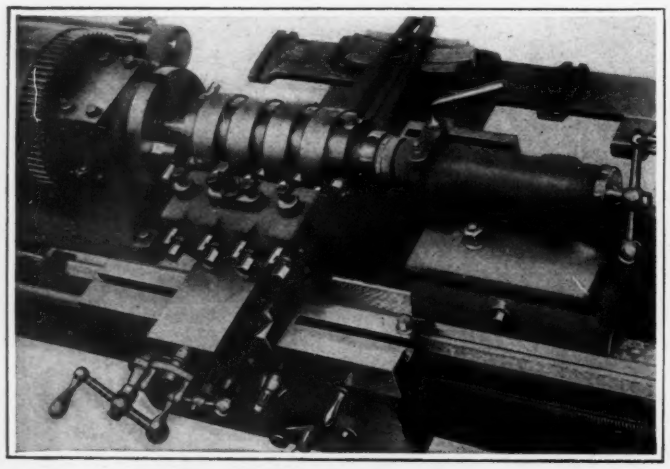


Fig. 10. Turning and crowning Pulleys

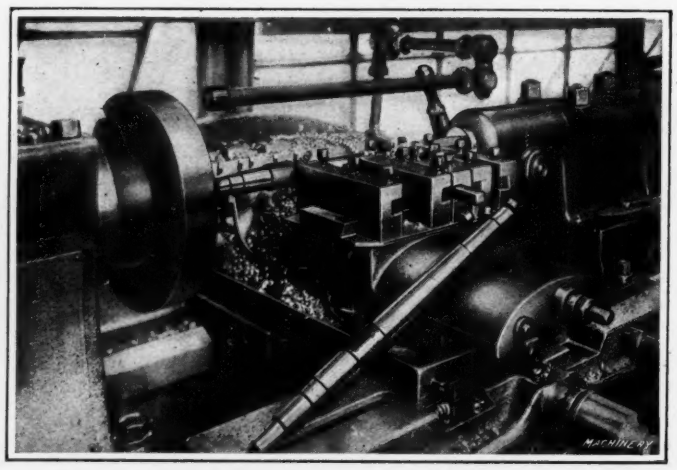


Fig. 11. Turning Armature Shaft with Gang Tools

A recently developed gang tool-block is shown in detail in Fig. 6. This has separate holders for four (or more) tools, and these holders are adjustable along the dovetailed upper surface of the base block. The latter fits into the T-slot of either the compound or the plain rest of the lathe. The tool-holders are reversible, as shown by the illustration, so that they may be placed either face to face, back to back, or back to face, to correspond to any reasonable distance between shoulders on the work at hand. Fig. 7 shows one of these gang tool-blocks mounted on the rear connected plain rest of a lathe, and the four-way tool-block on the compound rest. The positions of the gang and the four-way tool-blocks may be transposed, as in Fig. 8. In some cases, for example the armature

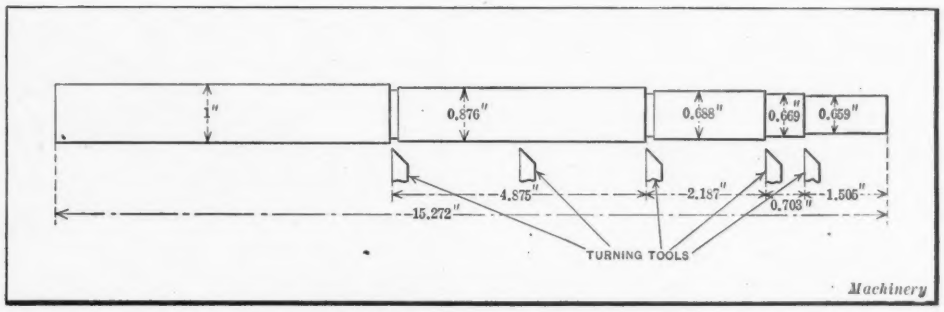



Fig. 12. First Lathe Operations on Armature Shaft

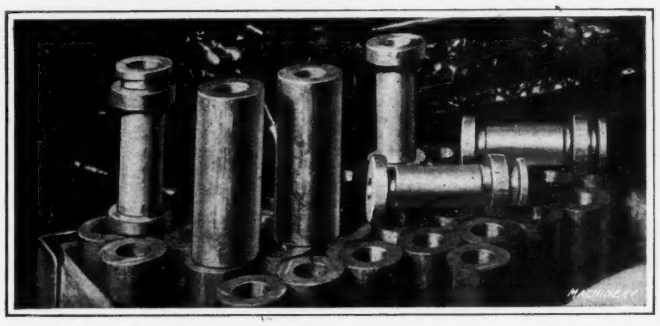


Fig. 13. Double Bevel Pinions after First Lathe Operations have been performed

shaft shown in Fig. 11, gang tool-blocks with adjustable holders are used in both connected compound and plain rests.

The uses of gang tools just outlined can best be illustrated by specific examples. The first two cases, dividing a roughing cut between front and rear tools and roughing and finishing at one pass of the carriage, require independent adjustments for both tools, which is shown in a general way in connection with chasing precision screws, and therefore will not be described separately. Following that are examples showing the adaptability of gang tools held in fixed positions relative to each other for a variety of lathe work, and indicating the great saving which gang tools and the manufacturing lathe effect in turning duplicate parts.

### Chasing Precision Screws

Fig. 9 shows a specially arranged carriage with two chasing tools for taking two cuts from a long lead-screw at each pass of the carriage. Each tool is carried in its own holder on a separate cross-slide and each slide has independent in and out adjustment by a cross-feed screw with a micrometer collar. Two special follow-rests are bolted across the front and rear wings of the carriage, one preceding the cutting tools and the other closely following them; a third rest between the two cutting tools supports the work from the rear.

Before starting a chasing cut, both tools are clear of the work. The first tool is fed in to the requisite depth, as read from the micrometer collar, and the power length-feed of the carriage is engaged. When the second tool is nearly up to the starting point of the cut, it is fed in to a little greater depth than the first tool, so that it will take a second chip. A number of cuts must be taken to complete a precision screw, because each cut is necessarily light to prevent distorting or tearing the work. By taking two cuts at each pass of the carriage, much time is saved.

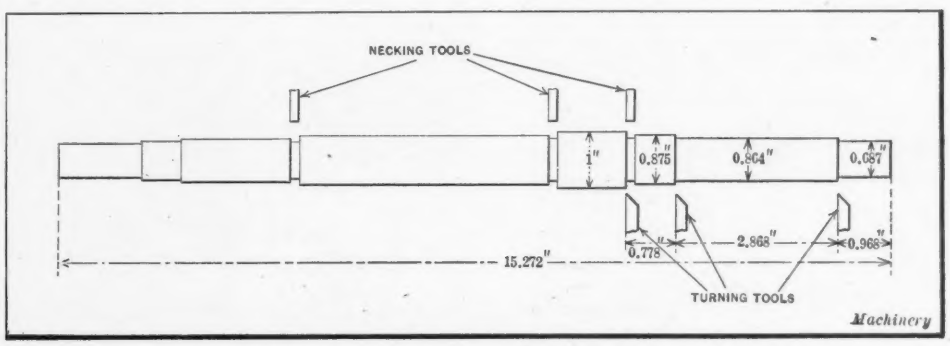



Fig. 14. Second Lathe Operations on Armature Shaft

### Turning and Crowning Pulleys

Fig. 10 shows four small pulleys mounted on an arbor and located by spacing collars at definite distances apart, also four tools fixed in a special block on the compound rest. The four cutting tools are placed the same distances apart as the pulleys, so that each tool starts to cut at the edge of one pulley and all feed simultaneously across the faces. A special crowning attachment is fastened to the back of the carriage. This consists of a sliding shoe working in a groove made in the form of an arc of a circle. As the carriage is moved forward by the power length-feed, the cross-slide is automatically moved gradually out and in. This causes the cutting tool to travel in a circular path and produces the desired crown of the pulley.

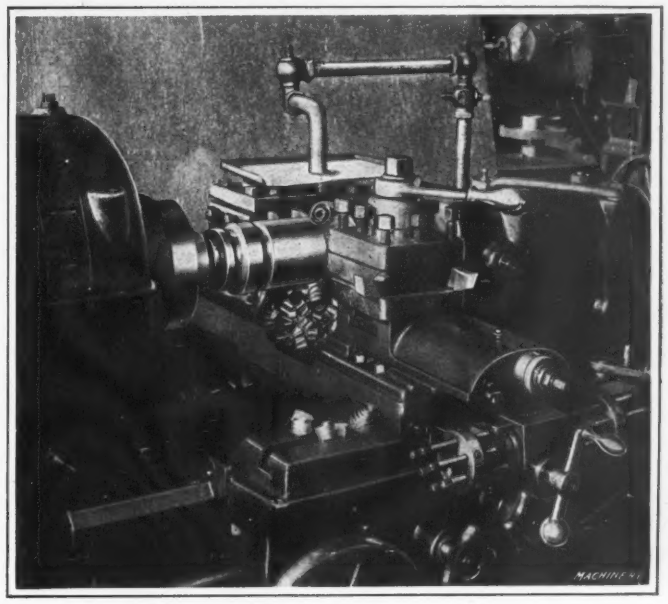


Fig. 15. Turning Double Bevel Pinions in Selective-head Lathe

In this illustration, the four pulleys are all of the same diameter; therefore, the four cutting tools are all set the same distance from the center. A similar rig is used for turning and crowning cone pulleys. Then the tools are set at different distances from the center, so that the three, four, or five steps of a cone pulley will all be turned simultaneously.

### Turning a Small Armature Shaft

The use of the manufacturing lathe with gang tool-blocks and adjustable tool-holders in both the compound and connected

plain rests is admirably illustrated in the case of the small armature shaft, machined as shown in Fig. 11. The shaft is 15.272 inches long over all, and 0.876 inch at the largest turned diameter; the material is 1-inch bar stock of 0.30 carbon "Corona" machinery steel; the speed of the work is 160 feet per minute; and the feed is 0.015 inch per revolution. An allowance of 0.010 to 0.012 inch is left for grinding. The shafts are cut to length, faced, and uniformly centered before being delivered to the lathe. While turning, the work is flooded with a heavy stream of cutting compound. This reduces heating of the work and tools, acts as a lubricant, and permits the use of a much higher cutting speed.

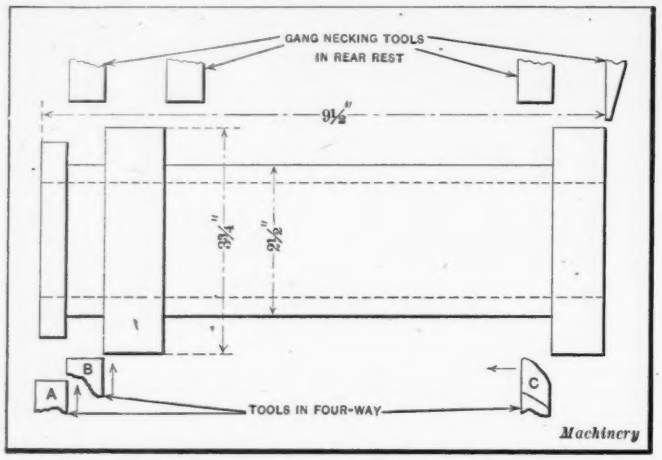



Fig. 16. Tool Diagram for First Lathe Operations on Double Bevel Pinion

For this and for similar pieces turned between centers, two dogs are provided. The operator removes the dog from a finished piece and adjusts it to the next piece to be turned while a piece is being cut. This saves the time that would otherwise be spent in "dogging." Shafts are frequently held in a chuck at the head end, instead of with a dog; the chuck can be set quickly, and it reduces the unsupported length of the work.

The first lathe operation on the armature shaft shown is to turn the diameters on the long end of 0.659 inch, 0.669 inch, 0.688 inch, and 0.876 inch, using a gang tool-block on the compound rest at the front. The arrangement of tools is shown in the diagram Fig. 12. The cut on the large diameter is divided between two tools, so that this length of 4.875 inches is turned with a carriage travel of not more than 2½ inches.

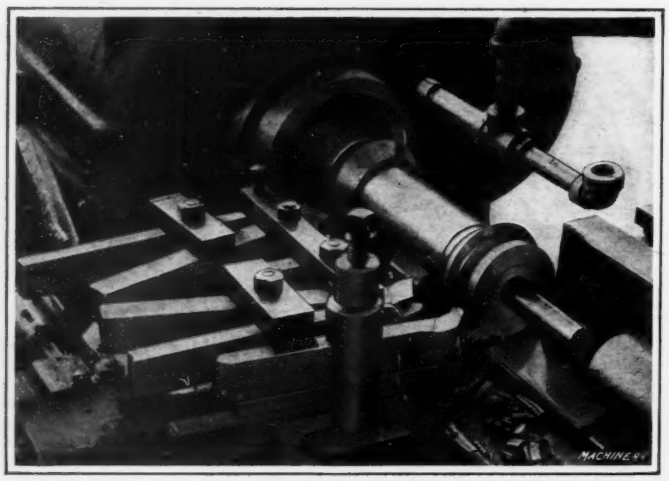


Fig. 17. Tooling for Second Lathe Operations on Double Bevel Pinion

The output on the first operation is 400 pieces in ten hours, or an average time, including handling, of 1½ minute each.

The second operation is to turn the short end diameters of 0.687 inch, 0.864 inch, and 0.875 inch with the gang turning tools carried on the compound rest at the front and also to neck, for grinding with gang tools, on the connected rear plain rest. The output for the second operation is 300 pieces in ten hours, or an average of two minutes each, including handling. Fig. 14 is a diagram of the tool lay-out in the connected compound and plain rests for the second operation. Many other shafts and studs that are turned with gang tools in this way are faced in the lathe and are necked at every shoulder. In such cases, it is necessary to use a gang of necking tools for each end instead of on the second operation only. A facing tool is carried in each gang of necking tools so that the ends are faced without making an additional operation.

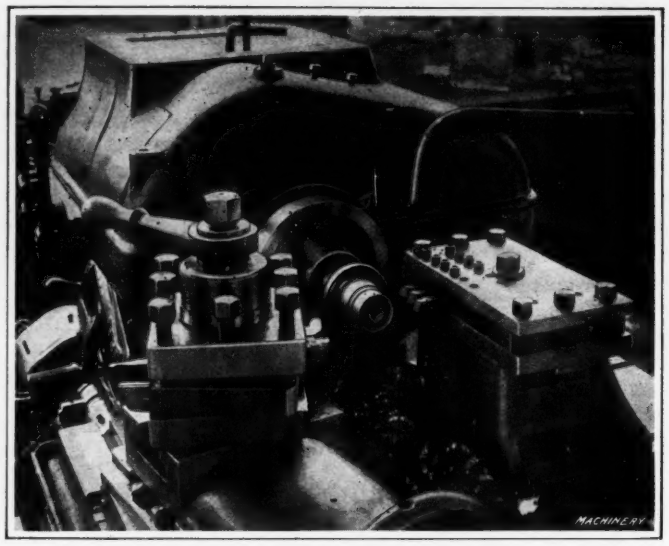


Fig. 18. Manufacturing Lathe Set-up for turning Roller-bearing Cone

### Turning Double Bevel Pinion

The stock for double bevel pinions as it is delivered to the lathe bored ready for mounting on the arbor, and several of the pinions after the completion of the first lathe operations, are shown in Fig. 13. A fully equipped selective-head manufacturing lathe is used, having a four-way tool-block on the compound rest and a gang tool-block on the connected rear rest. This piece is handled in two settings.

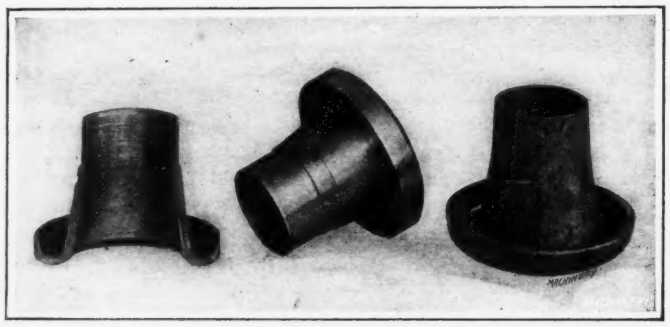


Fig. 19. Cones for Roller Bearings

Details of the tooling for the first setting are given in Fig. 15. The gang tools are fed straight into the work, necking at three places and facing one end. This is shown more plainly by the tool diagram, Fig. 16. The proper depth has been predetermined by the diameter stop. Other cuts at the same setting of the work are taken with tools in the four-way block. The broad turning tool *A*, which turns the reduced diameter

Fig. 20. Last Operation on Roller-bearing Cone

next to the headstock, is fed straight in; then the four-way tool-block is indexed and the next groove is finished with tool *B*. The tool-block is again indexed and the long diameter between the shoulders is turned with tool *C*. The carriage and the cross-slide positions for all of these cuts with both front and rear tools are located by the multiple stops for length and cross feeds, which have previously been set in the proper positions. Six pounds of chips per minute are turned off in this operation.

In the second setting, the work is reversed on the arbor and a group of five gang tools is used in the compound rest only. Feeding straight in with the cross-slide, these tools face the unfinished end of the job, form the bevel surfaces on which the gear teeth are subsequently to be cut, and form the back of the bevel. The set-up for this operation is shown in Fig. 17. The arbor on which the blank is mounted has a journal bearing inside of a bronze bushing in the tailstock spindle, instead of being merely supported by the tailstock center. This gives a solid support to the end of the arbor against the heavy cuts that are taken with both sets of tools.

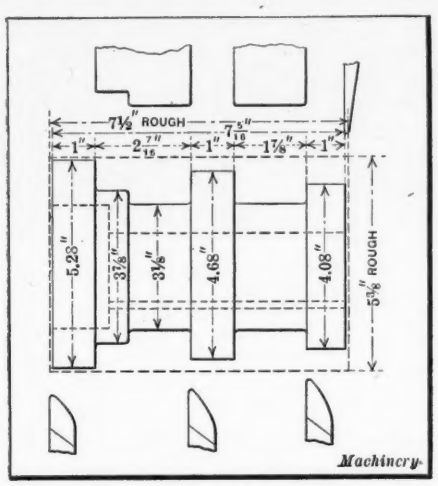



Fig. 21. Tool Diagram for turning and forming Cluster Gear

### Handling a Job on an Expanding Arbor

The previous examples have been of work turned between centers. In many cases where the piece is held in a chuck or on a stub arbor, gang tools are just as applicable. Fig. 18 shows a set-up on an 18-inch selective-head manufacturing lathe with a four-way tool-block on the compound rest and a special gang block on the connected rear rest, for turning a cone for a roller bearing. Fig. 19 shows rough and finished cones and a cross-section through a finished cone, which is

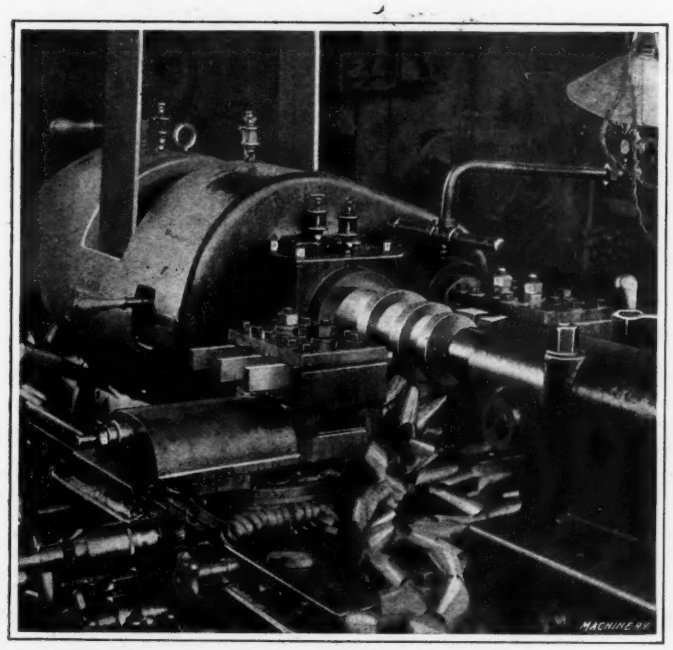


Fig. 22. Turning and forming Cluster Gear

made from a steel stamping. A novel point in this tooling is the use of the angular travel of the compound rest to turn the conical surface, making the set-up in such a way that the end of the travel of the compound-rest top slide forms a positive stop to locate the large diameter end of the conical surface. The average time for each cone, including handling,

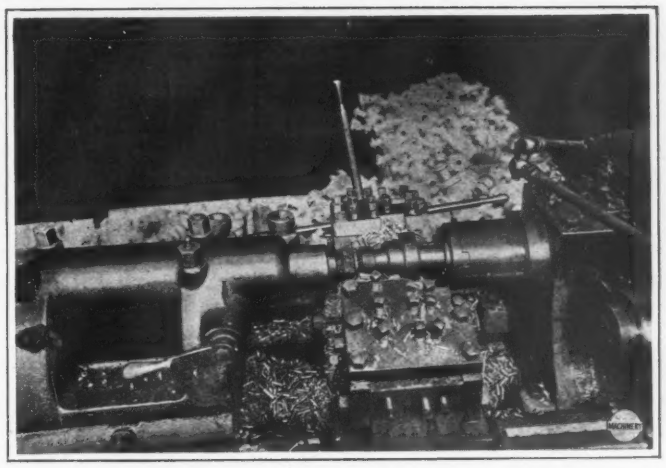


Fig. 23. Forming Three-step Counter Gear with Gang Tools

is 2¼ minutes each. The sequence of lathe operations is as follows:

1. Chuck cone on expanding stub arbor which locates it endways in a fixed position.

2. Feed cross-slide up to first diameter stop; also have compound rest set to correct angle for turning conical part or taper and note reading of graduated dial on compound-rest screw. Do not move compound-rest screw during this operation. Engage power longitudinal feed of carriage to turn large and small outside diameters simultaneously with two tools held in four-way tool-block. The length stop is set to trip the feed automatically at the proper point.

3. Hold carriage in last position against length stop. Set cross-slide to second diameter stop. Turn taper with rear tool of previous operation, using hand angular feed of compound rest and feeding against stop at end of travel of compound-rest top slide.

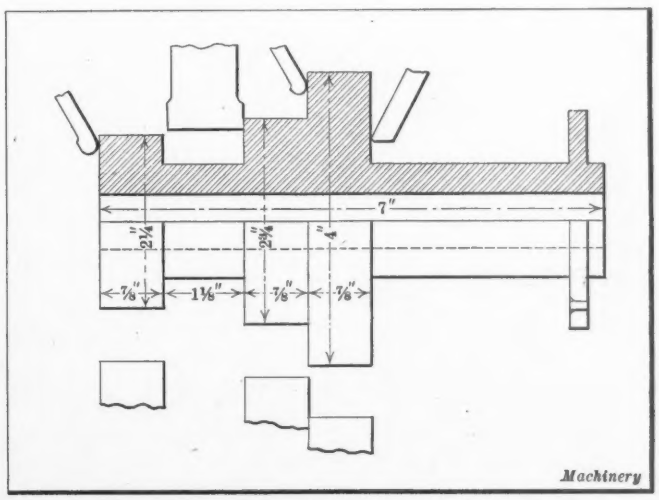



Fig. 24. Diagram of Tooling for Three-step Counter Gear

4. Move cross-slide out, feed compound-rest top slide to its original position, as shown by reading of graduated dial, and face inside of rim. Feed up to next length stop.

5. Locate carriage by length stop and feed cross-slide forward by hand, bringing into action gang of three tools in rear block. These simultaneously neck at both ends of taper portion and face small end of cone.

6. Revolve four-way tool-block to bring other pair of tools into position and set to proper diameter by next cross-feed stop. While one tool is forming inside of cup, the other tool is chamfering small end of piece. Fig. 20 illustrates this operation.

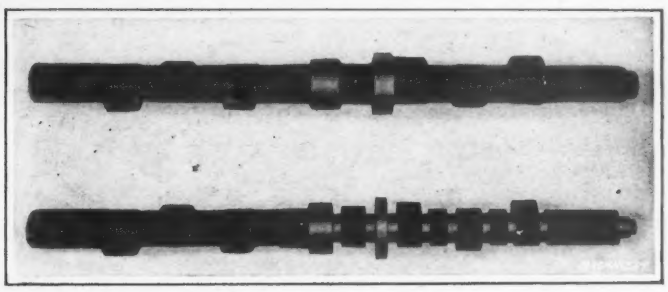


Fig. 25. Cam-shaft before and after First Lathe Operations on One End

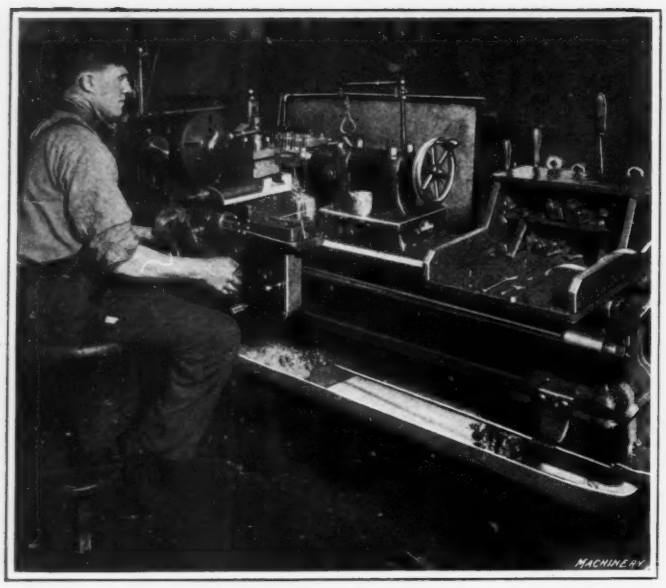


Fig. 26. Turning Cam-shaft

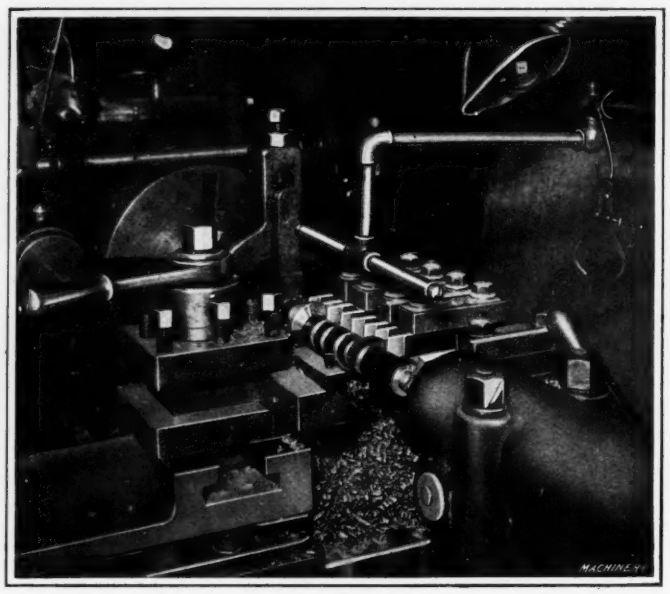


Fig. 27. Details of Tooling for Cam-shaft

### Turning a Cluster Gear

The cluster gear illustrated in Fig. 21 is made from a 5⅜-inch chrome nickel-steel bar of 0.25 carbon. As the heavy forming cuts taken on this piece require a stiff, powerful lathe, the job is done in a 24-inch manufacturing lathe, fitted with gang tools in both the compound and connected rear plain rests. Fig. 22 shows the set-up in the lathe. Before delivery to the lathe, the blank is bored, counterbored, faced on the large end, and keyseated. It is mounted on a special arbor with the faced end toward the headstock. This arbor has a shoulder to correspond to the counterbored part of the gear blank; and when the blank is slipped onto the arbor, it is forced up against this shoulder. A key in the arbor engages the keyseat in the blank to give a positive drive. The free end of the arbor is journaled inside a bronze bushing in the tailstock spindle.

When rough-turning, feed in the cross-slide to the first diameter stop and engage the power length-feed. The three turning tools in the gang on the compound rest rough-turn the outside diameters of the three gears to within 1/32 inch of size. Each tool continues cutting until it has fed across the face of each gear; then the automatic stop trips the length-

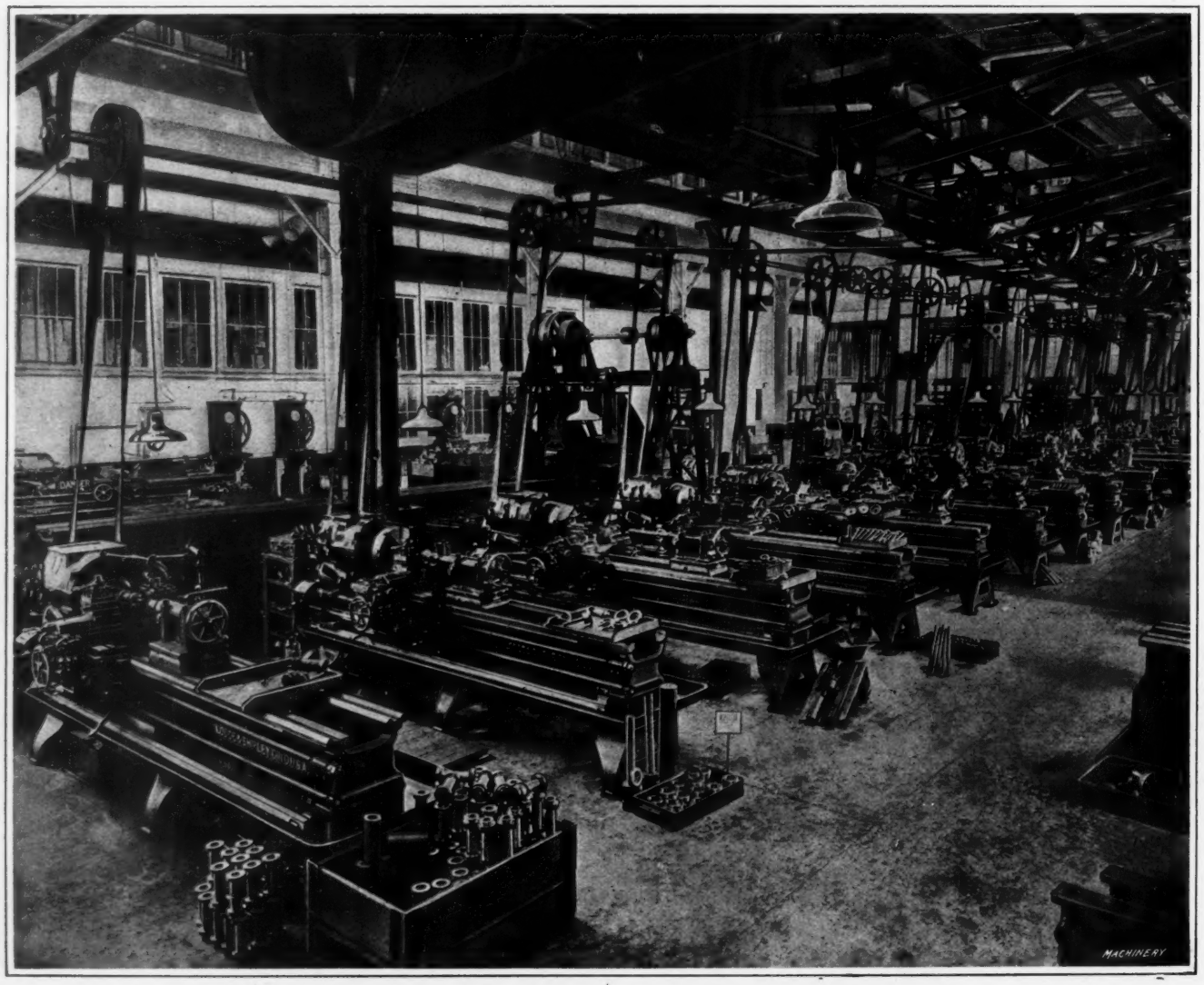


Fig. 28. Battery of 18-inch Selective-head Manufacturing Lathes

feed. In the forming operation, hold the carriage in the position just located by the length-feed stop. With gang forming tools and facing tool in the rear tool-block, rough- and finish-form the recessed diameters between the gears and the faces of the gears themselves, and face the end toward the tailstock, feeding straight into the work with the cross-feed screw up to the diameter stop. When finish-turning, return the carriage to its first position, set to the proper diameter as determined by the next cross-feed stop, and finish-turn the outside diameters with the three tools on the compound rest. This stock, when delivered to the lathe, weighed 38 pounds; after completing the lathe work, the cluster gear blank weighed 18¼ pounds. The total turning time was twelve minutes.

### Forming a Counter Gear

The three-step counter gear shown in Fig. 23 is a job similar to the preceding, but it is made from a 3½ per cent nickel-steel drop-forging, instead of from bar stock, and it is machined by forming cuts with gang tools in both front and rear holders, instead of using one gang for turning and one for forming. Because the cross-feed only is used, a large pilot wheel has been substituted for the usual ball-crank on the cross-feed screw. The arrangement of tools, with three straight forming tools in the rear holder and one forming tool and three facing tools in the front holder, is shown in the diagram Fig. 24. These gear blanks are machined all over at one setting. The first operation is to form with the rear tools and the second to form and face with the front tools. The output from this 18-inch lathe is 125 finished gear blanks in ten hours.

### Machining a Cam-shaft

Fig. 26 is a general view of an 18-inch selective-head lathe turning a six-cylinder automobile cam-shaft. Fig. 27 shows details of the tool equipment, with gang tools in the four-way tool-block on the compound rest and another gang of tools on the connected rear rest. The cam-shaft before and after this operation is shown in Fig. 25. This is another case where the cross-feed only is used. Each gang of tools is, in turn, fed straight into the work.

Before the cam-shaft is delivered to the lathe, the outside diameters of the pump gear and the center bearing have been turned, so the steadyrest may be used on the center bearing. After placing the shaft between centers and adjusting the steadyrest as shown, the gang of nine tools in the front holder is gradually fed into the work up to the proper depth, as determined by the diameter stop. These tools rough-face one end of the cam-shaft and rough out the spaces between the cams, bearings, and gears. Next, the nine finishing tools in the rear rest are brought forward to finish the places which have just been machined by the front tools. The rear tools are slightly wider than the front and finish the faces up to the diameter stop.

This operation is on one end of the cam-shaft. The other end is handled similarly. The stock left between the cams is turned off and the bearings are finished in subsequent lathe operations. The material is 5 per cent nickel and 0.18 carbon steel drop-forging; the speed of work is 220 revolutions per minute. The time for roughing and finishing one end as shown, including handling, is four minutes.

### A Lathe Department for Duplicate Part Work

Fig. 28 shows a row of selective-head manufacturing lathes, such as are used for rapidly and accurately turning duplicate parts as shown by the preceding examples. The lathe in the foreground is turning the double bevel pinions illustrated in Figs. 13 and 15; the next lathe is used for the threaded nut described in connection with Figs. 4 and 5. Groups of these finished parts may be seen at the ends of the lathes. Each of these selective-head lathes has the full manufacturing equipment: connected compound and plain rests with four-way tool-block or gang tool-block on the compound rest and high-duty tool-block or gang tool-block on the plain rest; multiple stops for length and cross feeds to duplicate shoulders and diameters; pan, pump and tubing, so that the work may be flooded with cutting compound.

Noteworthy features of this installation are that the lathes are placed at right angles to the lineshaft and driven, without a countershaft, in groups of four by constant-speed quarter-turn belts from a jack-shaft. This style of drive is possible with the selective head, because there are twelve mechanical spindle-speed changes obtainable through the headstock gearing and the belt is never shifted. This gives a nearly clear ceiling, which keeps down the investment in countershafts and belting and improves the lighting. Having all of the lathes at right angles to the aisles makes it possible to get several more machines into the same floor space without crowding, and greatly facilitates moving material.

* * *

## ALCOHOL AS FUEL

It is ten years since Congress passed the denatured alcohol act, permitting anybody to distil industrial alcohol free of government tax. It was then thought that this country would soon be flooded with alcohol in such quantities as to provide a new, cheap fuel, for it was officially stated that alcohol could be made from sugar cane, cornstalks, potatoes, barley, corn, wheat, rye, sugar beets, sweet potatoes, wood pulp, sawdust, apples, the waste of canneries, corncobs, many weeds and a thousand and one waste products of the farms and factories. And the government issued a bulletin—No. 268—describing the tubs, stills, etc., needed, and the best methods of producing alcohol.

The prospect was that every farmer would soon have his little still and turn his waste stuff into industrial alcohol, but the whole scheme was destroyed by the act itself, which required that every still must be registered and conducted under the direct supervision of an internal revenue officer; that no one would be allowed to make less than seven to ten gallons daily, and that no still could be shut down except by the revenue officer. The prospective alcohol industry instantly vanished. No farmer could keep an industrial alcohol plant running all the time, and he was not allowed to use his still occasionally or when he had a lot of refuse stuff to use up. And so alcohol has not yet come into general use as a fuel.

Now, however, a new field seems opening up. Henry Ford asserts that the world's supply of petroleum—and therefore of gasoline—is fast playing out and the day of alcohol fuel for automobiles and tractors is just dawning. He advises breweries, especially those in states that have recently gone dry, to utilize their properties in the making of industrial alcohol instead of the potable kind. But as yet there is not on the market any automobile equipped for the burning of alcohol. Doubtless it will come, for inventors are working hard to produce it, and they generally get what they are after. There are alcohol engines already in experimental operation, but they have not yet been so perfected as to be introduced into commercial use.

If the automobile of the near future can be run with alcohol, which is safer to handle than gasoline, cleaner and of less offensive odor, it will provide an inestimable boon in the way of a new fuel. The source of supply is inexhaustible, the process of distillation simple and cheap, and unless some gigantic corporation gets hold of and controls the industry, alcohol ought to be cheaper than kerosene and much preferable for fuel. It might, in time, be used in stationary engines, in locomotives, in steamships, and in many domestic ways; but, first of all, it would seem that invention must find some way of making it popularly and efficiently available for automobiles.—*Newark Evening News.*

* * *

A central clearing-house has been established by the British Minister of Munitions for the purpose of tracing and registering machinery that is idle or about to become idle. This clearing-house will try to see that contracts are placed with manufacturers having the available equipment; also that engineering contractors who have the facilities for particular purposes will be placed in touch with the Ministry and other government departments that will require their services. This clearing-house will also help contractors who are able to undertake additional or more suitable work, at once or in the future, to maintain continuous employment of their machines and labor.

## EXPERIMENT IN IRON ORE SMELTING

In connection with the course of study in electro-metallurgy given at the University of Pittsburg, Pittsburg, Pa., under the direction of Prof. S. L. Goodale, a small furnace has been used for experiments in ore smelting, such as running down iron

Fig. 1. Conducting the Experiment

ore into pig iron and smelting copper ore to matte, etc. Fig. 1 shows the general appearance of the furnace.

Fig. 2 shows the furnace in sectional elevation. A Harbison-Walker 9-inch by 13-inch stove tile was used as the basis in building the furnace. This has a 9-inch diameter circular flue opening, inside of which is the graphite block or blocks for crucible and bottom electric connection. The crucible chamber is about 5 inches in diameter and 5 inches deep; and the lower graphite block rests on an iron plate which is used for one of the electrodes, the lower graphite block serving to keep the bottom connection cool. Layers of granular carbon resistor are set between the two graphite blocks, and a good connection is made between plate and graphite by powdered graphite. Surrounding the tile is a wall of porous insulating brick, 2 inches thick; and a slab of firebrick is used as a cover. The iron and slag are tapped through a small hole, but this feature gave trouble, and in future runs the furnace will be bound solidly together and mounted on trunnions so as to pour out the metal at the end of the run. A 2-inch top electrode of graphite was used. The furnace takes about 30 K. V. A. to work fast enough, and the regulation of the current under the transformer limitations is rather difficult. While these runs are made on a small scale, they serve to give the students practice in manipulation, and illustrate the main principles of the operation as conducted on a commercial scale.

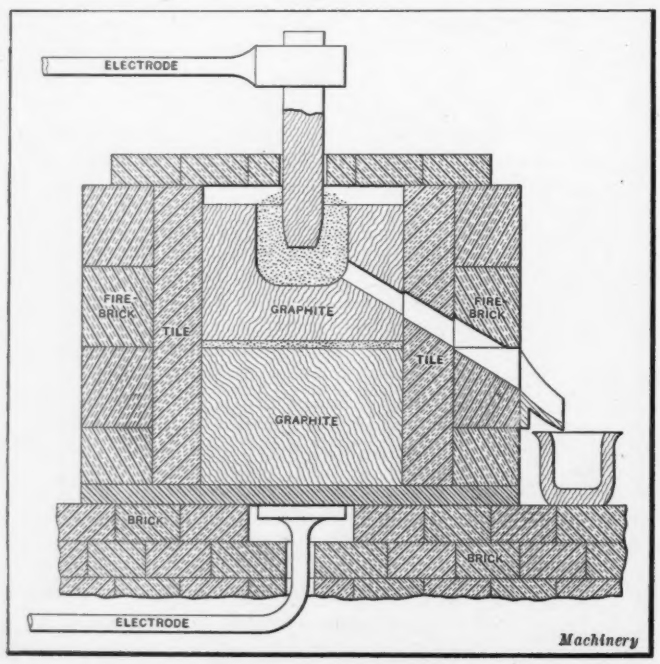



Fig. 2. Construction of Furnace

Fig. 3 shows the general lay-out of furnaces and control for the electric smelting work. Current is purchased from the Duquesne Light Co., from one phase of a two-phase supply, being stepped down in a transformer outside the building from 2200 volts. The leads come in through the circuit breaker to a regulating transformer especially designed for this installation. The regulation is such that current can be drawn at any voltage from 5 to 220, in steps of 5 volts each, by the manipulation of six double-throw switches mounted on the transformer. This is a highly satisfactory equipment for its capacity, which is limited to about 600 amperes at voltages of 110 or less, and to 50 K. V. A. at higher voltages, although having a generous overload capacity.

The larger furnace to the left in Fig. 3 is an upright shaft type with a top and a bottom electrode and a lining of chrome brick. The shaft is 26 inches deep and 11 inches diameter, and the ¼-inch sheet-steel shell has an outside diameter of 30 inches. The loss of heat by radiation from this furnace

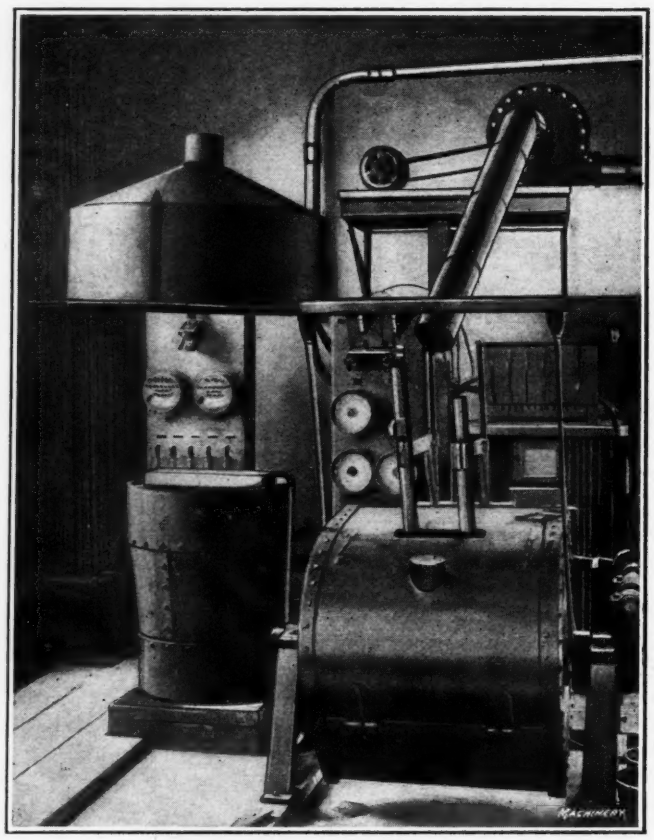


Fig. 3. Furnaces and Switchboard Equipment

is excessive; and it should have been built about 5 to 8 inches larger, with an insulating brick layer just inside the shell. The tilting furnace is strongly built of ¼-inch steel plate, and is lined with magnesite down to a smelting chamber of about 9 by 18 inches. The over-all length is 37 inches; and the shell might also have been made somewhat larger to permit of a more thorough heat insulation.

The switchboard back of the tilting furnace, on which a large control switch is also to be mounted, holds ammeter, voltmeter and wattmeter, and an integrating wattmeter is to be added. On a shelf directly above this board is a powerful exhaust fan and motor for use when a run is in progress that produces noxious fumes. The intake to this fan is shown just over the tilting furnace, but may also be shifted to the large hood. The switchboard at the left was formerly used in connection with direct-current experiments, and is now used in connection with the water pipe rheostat in the corner, and the alternating current. On arc experiments on a small scale it is far more convenient to use a fairly high voltage with a rheostat in the circuit than to be more economical of power and try to use a low voltage. C. L. L.

# LETTERS ON PRACTICAL SUBJECTS

We pay only for articles published exclusively in MACHINERY

## KEEPING TRACK OF PATTERNS

In the plant where the writer is employed, it is necessary to keep track not only of our own patterns but of many belonging to our customers as well. This is done by means of a card index. A separate card is filled out for each pattern, and these cards are grouped behind a guide card bearing the customer's name. The record is itemized and shows whether the pattern is of wood or metal. Core-boxes are entered in the same manner. The receiving clerk makes a record of the pattern number, also the customer's order number for the castings. The office is then notified of the arrival of the pattern and the date is noted on the card. When patterns are returned with the castings, a record of the fact is made on the card. In order that there may be no slip-up in returning patterns, they are added to the shipping order for the castings. For example, the shipping room's order will read: "Ship to John Smith 100 brass castings No. 208, 1 metal pattern No. 208, 1 metal core-box No. 208." While the shipping clerk will make a part shipment of castings if so instructed, he will hold the final shipment until the foundry delivers the patterns as called for on his order.

Some patterns are left at the plant indefinitely; so when a customer requests the return of his pattern, if there is no order on hand for castings, a regular shipping order is issued, as in the case of castings, and a notice is sent to the foundry to forward the pattern to the shipping room. This shipping date is then entered on the card in the same manner as when patterns are returned with castings. When a pattern cannot be otherwise identified, a rough pencil sketch is made on the card. By this method it is possible to keep a fairly accurate record of the comings and goings of miscellaneous patterns. This simple method has eliminated all trouble in accounting for patterns not owned by the plant, and at the same time it has kept the foundry from being littered up with patterns or castings for which it has no order.

Jersey City, N. J. — H. D. MURPHY

## FLEXIBLE BLANKING TOOLS

In punch and die work every new piece to be made requires its own blanking die, which is stored away as soon as the order is completed, and after being kept on file for a year or two lands in the scrap heap. This means a waste to the manufacturer; therefore it has been the aim of many engineers and tool designers to develop a more inexpensive and economical die design. The plan of making a die of small blocks that can be used later for other dies is shown in Figs. 1 and 2. In Fig. 1, the die consists of tool-steel blocks *A* set in a cast-iron die-shoe *B*. They are held in place by a templet *D* and by pouring molten lead into the die-shoe. Chunks of rubber *C* put into the die serve as a knock-out. The punch-blocks *E*, Fig. 2, are fastened in a cast-iron holder *D* in the same manner.

Fig. 3 illustrates the die-blocks, and Fig. 4 the punch-blocks, and it will be seen by reference to these illustrations that there is a difference in the shape of these blocks. This difference is

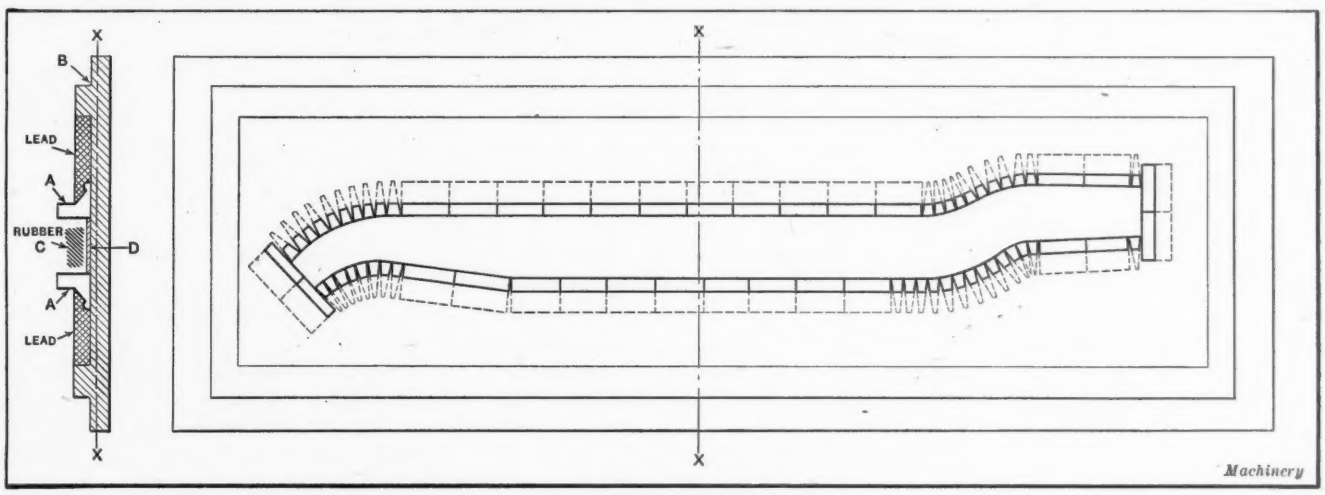



Fig. 1. Flexible Blanking Die

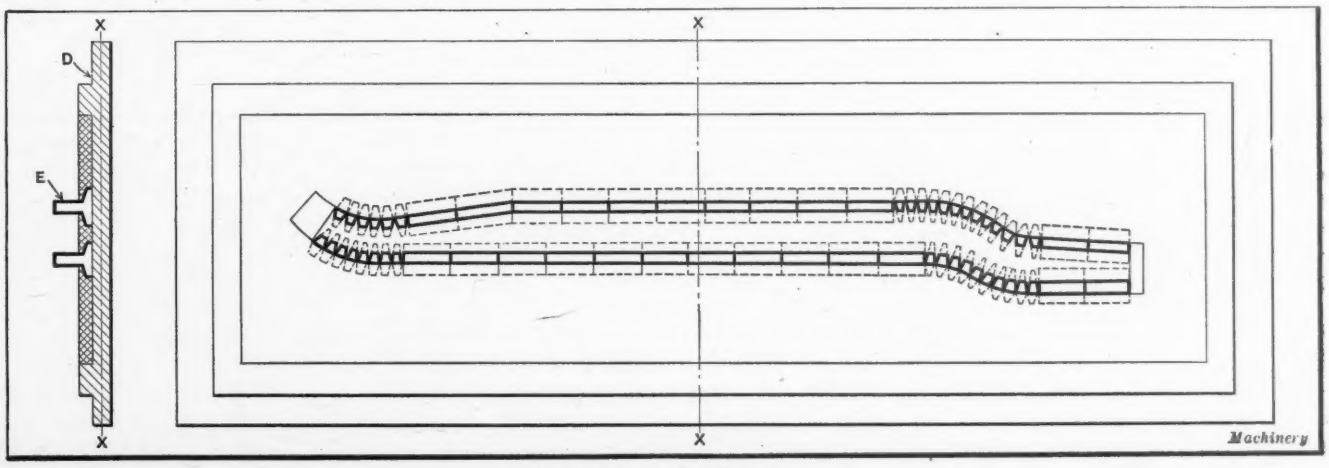



Fig. 2. Flexible Blanking Punch

necessitated by the different blanking stresses and the limited space for the punch-blocks. The blocks are shaped in a milling machine with a form milling cutter, cut to length, hardened and ground, and put in stock for future use. This style of blanking tool has been used for some time by the A. O. Smith Co. for blanking automobile side rails and cross-bars, also for gussets and many other pieces for which dead accuracy in the blank is not required.

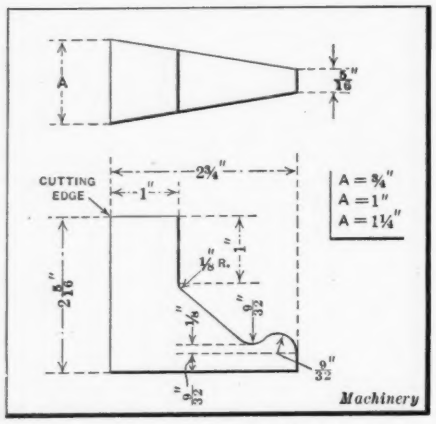



Fig. 3. Die-block used in Die shown in Fig. 1

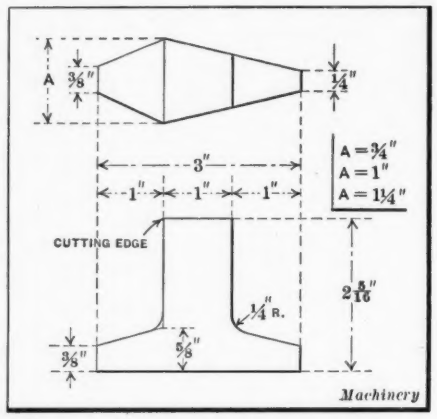



Fig. 4. Punch-block used in Punch shown in Fig. 2

Milwaukee, Wis. P. BALDUS

## RELATION OF PERIPHERAL SPEEDS TO SPINDLE PULLEYS IN GRINDING

Grinding-machine and grinding-wheel catalogues generally contain a convenient reference table of correct wheel-spindle speeds for peripheral rates of 4000, 5000, 6000 and 6500 feet per minute. These tables, however, are computed for full-size wheels and are not correct for wheels reduced by wear. To compensate for this wheel wear, many grinding machines, whether for cylindrical or wet-tool grinding, snagging, etc., are made with two steps on the pulley. Then a worn wheel may be speeded up to its initial peripheral speed by shifting the spindle belt onto the smaller spindle-pulley step. To insert an auxiliary table of spindle speeds in a general wheel catalogue would be out of the question, as the varied diameters of the smaller spindle pulleys on different makes of grinding machines are legion. To publish an additional table of spindle speeds, even though the machine itself might be specified, might lead to confusion. So it has been left to the operator to shift his belt from the larger spindle pulley to the smaller when he thinks the change should be made. As the cutting action of a wheel often depends to a great extent on its surface speed, the time for making this change should be determined by means of a definite formula rather than by guesswork.

For instance, a 6-inch Norton plain grinding machine with a spindle speed of 1773 revolutions per minute, for a recommended peripheral speed of 6500 feet (as figured for a full-size 14-inch wheel for this size of machine), has two steps on the spindle pulley; the large step is 5.5 inches in diameter and the small step 4 inches. What should be the minimum diameter of the wheel before the belt is shifted to the smaller step in order to obtain an exact peripheral wheel speed of 6500 feet?

As the spindle makes 1773 revolutions per minute when the belt is on the large pulley, its speed with the belt on the smaller is $5.5 : 4 = x : 1773$, or

$$\frac{5.5 \times 1773}{4} = 2437.875$$

revolutions per minute. To obtain the same peripheral speed as when the belt is on the large pulley, the diameters of the grinding wheel should be $14 : x = 2437.875 : 1773$, or

$$\frac{14 \times 1773}{2437.875} = 10.1813$$

inches. Therefore, when the grinding wheel has been worn down to a diameter of 10.1818 inches, or approximately 10 3/16 inches, the spindle belt should be shifted to the smaller step of the spindle pulley to obtain a peripheral speed of 6500 feet per minute. The method used in this example may be reduced to a formula for use with any make of grinding machine having a two-step spindle pulley.

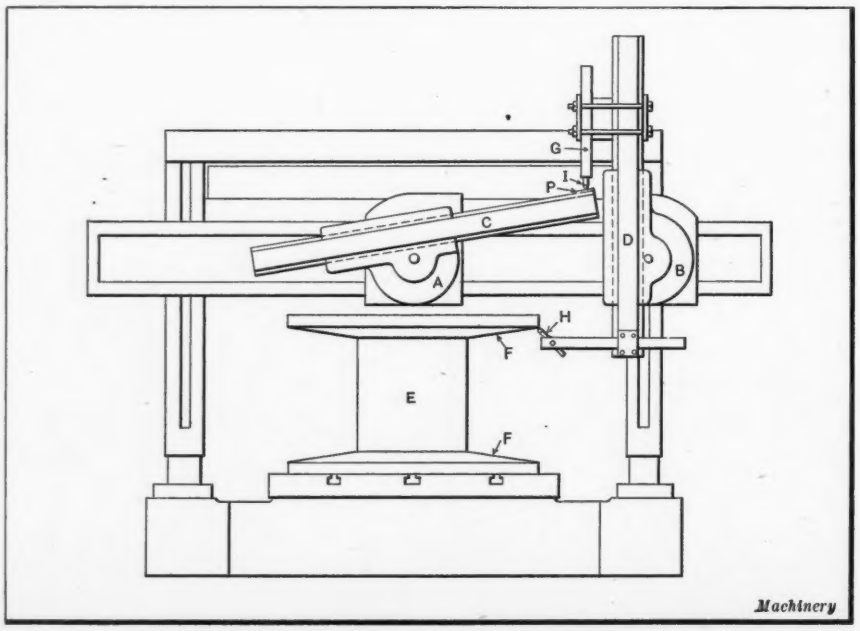
Let $D$ = diameter of wheel, full size;
$D'$ = diameter of wheel, reduced size;
$d$ = diameter of large pulley step;
$d'$ = diameter of small pulley step;
$V$ = revolutions per minute of spindle, using large pulley step;
$v$ = revolutions per minute of spindle, using small pulley step.

Then $$\frac{dV}{d'} = v; \text{ and } \frac{DV}{v} = D'$$

Worcester, Mass. ROBERT J. SPENCE

## FACING ANGLES ON BORING MILL

The writer recently had occasion to machine a cast-steel drum 7 feet in diameter, 5 feet high, weighing 18,000 pounds. Its general shape is shown at $E$ in the accompanying illustration. The drums were finished all over and the inside of the flanges $F$ were faced at an angle with a rise of 1½ inch to the foot. As it was impracticable to attach the tool for facing these flanges to the boring rams $C$ or $D$ when inclined to the required angle, the ram $C$ of the left-hand saddle $A$ was used as a guide for ram $D$, and inclined to the angle it was desired to face. Bar $G$ with a point $I$ at its lower end, was clamped to the upper end of ram $D$, as shown. The counterweight chain, not shown, was disengaged from saddle $A$ but remained connected to saddle $B$. The counterweight, however, was reduced somewhat to permit ram $D$ to rest more securely on the end of ram $C$ through bar $G$; the vertical feed of ram $D$ was disengaged to permit of this. As tool $H$ is fed across the flange by the traverse feed of the saddle $B$, the ram $D$ feeds down by gravity, following the incline of ram $C$, which is fed in the same direction as the tool $H$. The plate $P$, being free to move on ram $C$, compensates for the slight difference between the traverse feed of saddle $B$ and the vertical feed of ram $C$. It was necessary, of course, to reverse the drum in order to machine the flange on the other side.

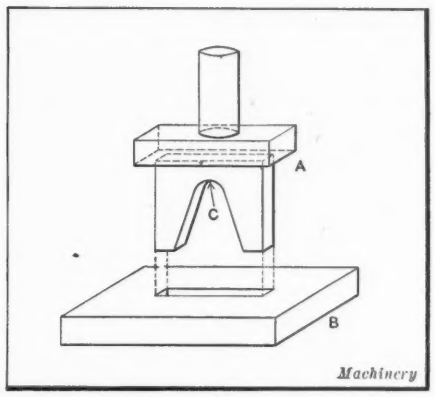



Boring Mill arranged to face Flanges of Large Steel Drum

W. WHEATLEY
Butte, Mont.

## MAKING FERRULES FROM SHEET STEEL OR BRASS

In the manufacture of steel store fixtures, etc., it is necessary to use a number of ferrules for supports at rivets, which hold the two faces, or sides, of a panel together. To use steel tubing for this purpose is expensive because of the waste involved. The accompanying illustration shows a tool for making ferrules from sheet steel or brass, without waste, that is used with success by a concern in the Middle West.




Punch and Die for making Ferrules from Sheet Steel

The tool consists of a punch *A* and a die *B*. The steel is cut into strips that are as wide as the circumference of the ferrule. The slot in the die *B* must be as wide as the ferrule is long, that is, ½ inch wide for a ½-inch ferrule. The radius *C* must be the same as the radius of the ferrule. The metal is placed between the fingers of the punch *A*. Then as the punch travels through the die, it shears the metal from the outer edge; the final cut-off at *C* forms the perfect circle of metal. By the application of a stop on the die, no material is wasted.

Chicago, Ill. J. A. ZELLER

## CARE OF THE EYES IN MECHANICAL WORK

When one gets a bit of foreign matter "in the eye," as it is called—meaning, merely, between the eyeball and the eyelid—about the easiest thing to extract it with is a long graphite lead-pencil point. This is firm enough to keep the eyelid out of the way, and sufficiently smooth—it is, in fact, slippery—not to scratch either the eyeball or the inner surface of the lid. It should be newly sharpened with a clean knife so as to avoid infection.

New York City. ROBERT GRIMSHAW

## REMOVING AND APPLYING TIGHT NUTS

In removing stubborn nuts, up to, say, 1¼ inch, it is usually the practice, after all wrench, chisel, and hammer methods have failed, to heat the piece in a forge and then remove the nut. If the job is not portable, a torch must be used. It frequently happens, however, that a job cannot be carried to a forge and a torch may not be available. If a good handful of cotton waste is twisted into a loose rope, saturated with oil, wrapped loosely around the refractory nut, and set afire, it will nearly always expand the nut sufficiently to break the rust joint, and permit the nut to be readily removed. The waste should be permitted to burn to a crisp, and any nut that still remains obstinate may as well be cut off. In places where fire must be handled with care, a piece of tubing may be placed over the burning waste. To allow for air, the diameter of this tube should be about six times the size of the nut to be removed, and it should be not less than three feet in length.

By the application of the expansion principle, nuts may be screwed onto bolts so tightly that they will not work loose. In this case, the bolt should be turned up and fitted to the nut, just so it will "promise" to start but will not enter the nut. It is then placed in position and the nut is heated and turned on. The allowance for a shrink fit, in this case, is small, so there will be time to place the nut before it sets. Even though the bolt is cold, and will cool the nut, the shrinkage allowance will permit the nut to be moved on the bolt when only moderately hot. This makes one of the most dependable lock-nuts. Of course it is very likely that a torch will be required to remove the nut; but if that is not available, a piece of waste saturated with oil may be used in its place.

Plainfield, N. J. J. B. MURPHY

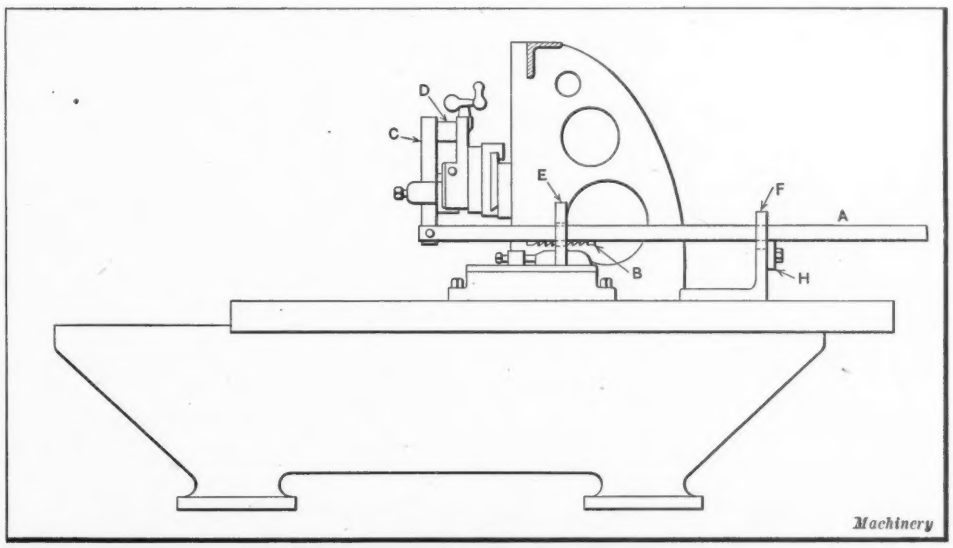
## HOLDING STEEL PIECES TOGETHER WHEN SWEATING

If trouble is experienced in holding pieces of steel together when sweating, the pieces should be magnetized after they have been tinned. If they are then placed together in their proper relation, and have a fairly good flat surface, they will not separate unless given quite a jar. If the pieces do not stick after they have been magnetized, one of them should be reversed end for end. The failure to stick is due to the fact that like poles repel and unlike poles attract. In other words, when the steel pieces are magnetized, if they are of any form except circular, a magnetic pole is created at each end of each piece. As a south pole is formed at one end and a north pole at the opposite end, if the two magnetized pieces do not stick together, it is safe to assume that the two north poles of the pieces are together. By turning one of the pieces end for end, the unlike poles are brought together and each will attract the other.

Bridgeport, Conn. JAMES MCINTYRE

## KEYSEATING WITH A SMALL PLANER

The cutting of keyways in milling cutters and work of similar size can be done quickly on a small planer. A cold-rolled round bar *A*, with a slot and hole in the end for attaching it to the toolpost bar *C*, and a slot seven inches from the end in which to place the cutter is the main equipment. The cutter *B* is the width of the slot, four inches in length, and projects far enough out of the bar to give the necessary depth of cut. The action of the toolpost swivel is stopped by a block *D* behind the toolpost bar. A slotted angle-plate *F* at the other end provides for the alignment of the bar, and a cross-bar *H* on the angle permits adjustment for depth. The cutter *E* to be slotted is held in the vise. The pressure for cutting is exerted by hand and is relieved on the back stroke. The alignment of the cutter and the bar is provided for by a ring that slips on the bar and into the work while clamping it in the vise. Fast and accurate work can be obtained in this manner, equaling that done on an ordinary keyseating machine.




Arrangement for keyseating Milling Cutter on Planer

R. M. BLAKELY
Dayton, Ohio.

## QUICK METHOD OF MAKING ELLIPTIC BROACH

Some time ago, a rush order for an elliptic broach, Fig. 1, came into the shop. It was to be made of "Ketos" steel, about 40 inches long, with 107 teeth, a land of 1/16 inch, and a slight taper. First a forging was made and four centers were laid out in each end for the planing operation. The work was then secured to the planer, being supported by a dead center at one end and an index center at the other. After being planed to

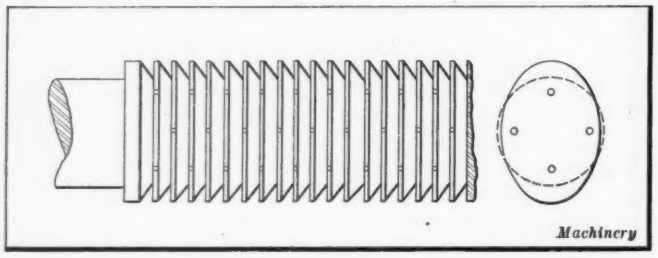



Fig. 1. Elliptic Broach cut on a Lathe

the elliptical form by successive centering and indexing, the piece was filed to gage and the teeth were cut in a milling machine, which was an exceedingly slow operation. The tool cracked while being hardened. As production work was being held up, another broach had to be made as quickly as possible. This one was planed and filed like the first one, but during these operations, a lathe was rigged up with an attachment, Fig. 2, to use in place of the milling machine for milling the teeth. The base of the attachment was a forging having two uprights, which were bored for two shafts, one being for the belt pulley *A* and the other for the cutter *C*. These shafts were ¾ inch in diameter and cut from cold-rolled screw stock. Two gears 2½ inches in diameter and 24 pitch were taken from a standard lathe, and a 4-inch pulley was used for the belt drive. For overhead power, a 10-inch pulley was put on the main lineshaft and a countershaft from a watch lathe was erected directly over the apron of the lathe, which was connected by belt drive to the pulley on the rigging. The power thus obtained was sufficient to drive the cutter. A roller *B* of the same diameter as the cutter was attached to the slide

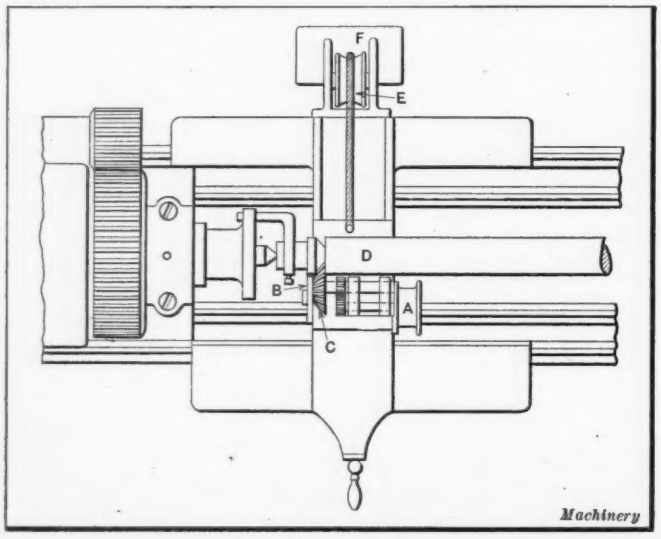



Fig. 2. Attachment for cutting Broach on Lathe

of the lathe and held against the broach. This arm was made adjustable, and allowance was made for the cutter to be fed into the work by the rest screw. This attachment was secured to the compound rest in place of the toolpost. The cross-feed screw was removed and a weight *F* was attached to the slide by means of a cord, which ran over pulley *E* fastened to the way of the lathe. This cord, kept taut by the weight, held the roller *B* and cutter *C* in contact with the revolving work. A bushing with three set-screws, which provided adjustment, was slipped over the broach; this allowed the work to be held by a steadyrest. Another steadyrest was placed on the round part of the broach. In this way chattering was reduced to a minimum.

Two stops were used to locate the carriage for the successive cuts. After one cut was taken, the stop nearest the headstock was taken off and clamped into position ahead of the other. The carriage was then run gently against the stops. By this method, uniform spacing of the teeth was obtained. Very little filing was required to finish the broach milled in the lathe, as compared with the one cut in the milling machine. The time taken for rigging up for the job was five hours, but by using the lathe for cutting the teeth, about forty-five hours was saved.

New Haven, Conn. ERIC LEE

## PROBLEM IN ALGEBRA

The following method is offered for solving the simultaneous equations $x^2 + y = 7$ and $x + y^2 = 5$, given by J. G. K. in the November number of MACHINERY. The value of $x$ and $y$ can be easily found by the method of successive approximations, using a table of square roots as follows: Take the greatest value for $x$, in the second equation that will make the right member positive, for the first approximation, and solve for $y$. Substitute this root in the first equation and solve for $x$. Substitute this value in the second equation and solve for $y$, and so on until the values found are the same for $x$ and $y$ in both equations. These results can then be tabulated as in the accompanying table.

| $y^2 = 5 - x$ | | $x^2 = 7 - y$ | |
|---|---|---|---|
| $x$ | $y$ | $y$ | $x$ |
| 2.0000 | 1.7320 | 1.7320 | 2.2952 |
| 2.2952 | 1.64462 | 1.6446 | 2.3142 |
| 2.3142 | 1.63884 | 1.6388 | 2.31542 |
| 2.3154 | 1.63847 | 1.6385 | 2.31549 |
| 2.3155 | 1.6384 | 1.6384 | 2.3155 |

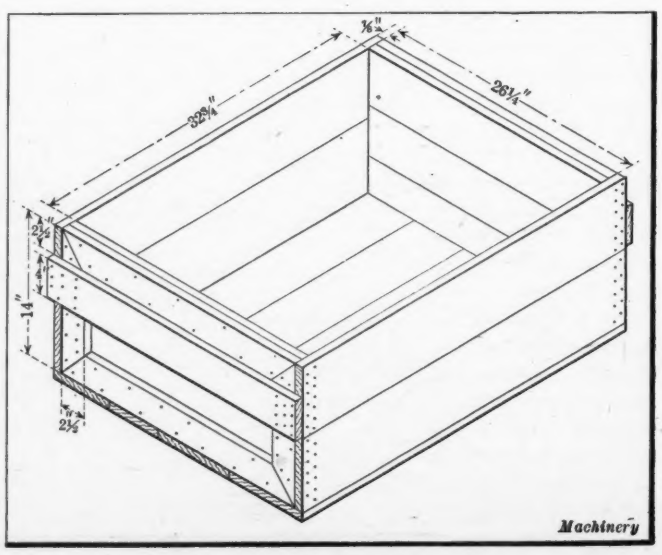
*Machinery*

The method of successive approximation is not only easier, but has the advantage that the work checks itself (except the last operation).

Cleveland, Ohio. WILLIAM W. JOHNSON

## PRESS-ROOM BOXES

In the November number of MACHINERY is described a box truck for transporting work step by step. While this truck has many good features, the following may be of interest. The accompanying illustration shows a box used in a press-room where small sheet-metal and wire parts are made. This box is placed on a platform beside the operator and, when filled, one or more boxes may be placed above it and also filled. When




Box for transporting Work in Press-room

the job is completed or the stack of boxes becomes too high, a transfer truck is run under the platform and the entire load moved where desired. When well made of pine or basswood these boxes will last for a long time. The four-inch strip on each end is a convenient handle, especially when it is desired to move a box that is only partly filled with work.

Beaver Dam, Wis. S. W. PALMER

As far as possible, metal should be used instead of wood, so as to keep the fire risk low.—EDITOR.

## HARDENING PLUG GAGES

The writer has recently had trouble with hardening plug gages. They seemed to stand the file test, but after lapping showed soft spots. The trouble evidently was in the steel, although several brands of carbon tool steel were tried, and all worked out the same. After they were heated to about 1500 degrees F. for two or three hours in a cast-iron box packed with charcoal, the gages were satisfactory. The charcoal, no doubt, had a slight carbonizing effect all over, but to a sufficient depth on the soft spots to render them hard enough for all practical purposes. The plugs were rough-turned to 0.015 inch over size before packing, and quenched from pack heat.

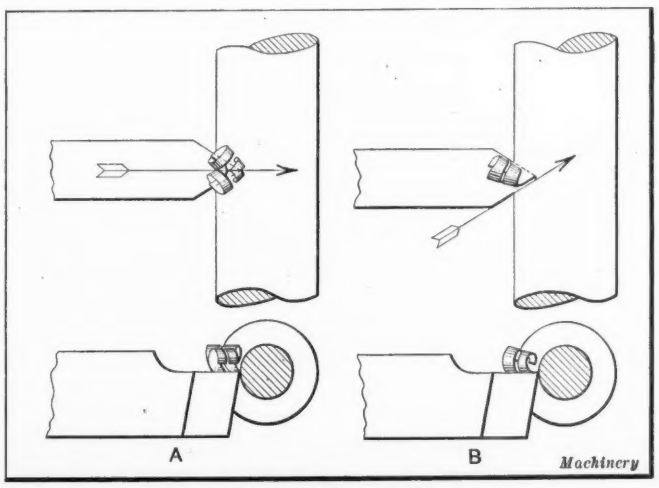
Urbana, Ohio. F. D. RIFNER

## CUTTING THREADS

In the last few years, modern shop management has awakened shop superintendents and foremen to their full responsibilities. The demand for capable men, the possibility of developing material on hand, and the era of time study investigation and analysis have been so fully advertised and exploited that it seems incredible that shops can be found where the direct antithesis exists. Yet in a recent visit to a factory a glaring illustration of this was found. In a shop where ordinary good practice prevails, men were cutting threads with a 90-degree advance to the center line, whereas an advance along a 60-degree line would do the work in one-fourth the time, avoid a ragged thread, and save both tool and temper.

The accompanying illustration is not a technically correct one, but it illustrates the effect of the chip on the tool to better advantage and may be readily comprehended by the average man and the apprentice. A straight-in advance, as shown at *A*, has a chip on each side and on the point, exerting a pressure in such a way that it will result in breaking down the point. At *B*, the cut is taken the same as any cut in a lathe, and the work is done far more satisfactorily and in less time. Just why machine-shop foremen allow the 90-degree advance to be used is a question. Time and again the writer has observed that this and other practices are permitted, not because of lack of equipment or facilities, but because of indifference. Not only are lathes equipped with compound rests allowed to remain idle while others are being used, but on lathes so equipped the compound rest is not employed.

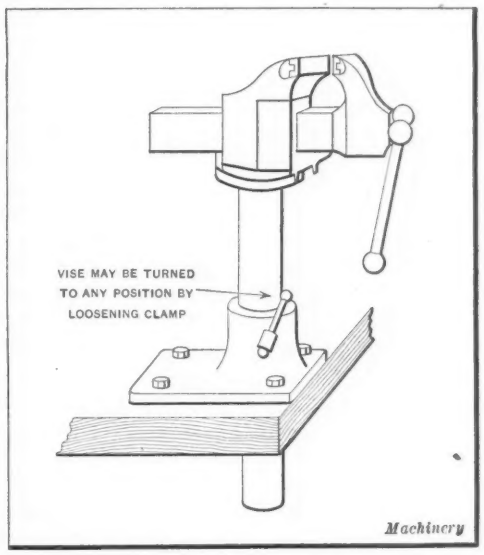
Indianapolis, Ind. F. E. METZLER




Wrong and Right Ways of cutting Threads

## VISE ADJUSTABLE FOR HEIGHT

Some progressive vise manufacturer would be taking a step in the right direction, it seems to me, were he to put on the market a vise that could be adjusted to different heights. This would be a marked improvement, and would be appreciated especially by tall men. They are now obliged to bend over at an angle of 45 degrees, more or less, which is an uncomfortable position, to say nothing of the strain on the nerves and the suspender buttons. A few men consider a filing job a snap, and before beginning get the most comfortable stool in the room and place their feet on a box. But most men prefer to tackle a filing job with both feet on the floor, as a standing position gives a freer arm movement and better control over the file.



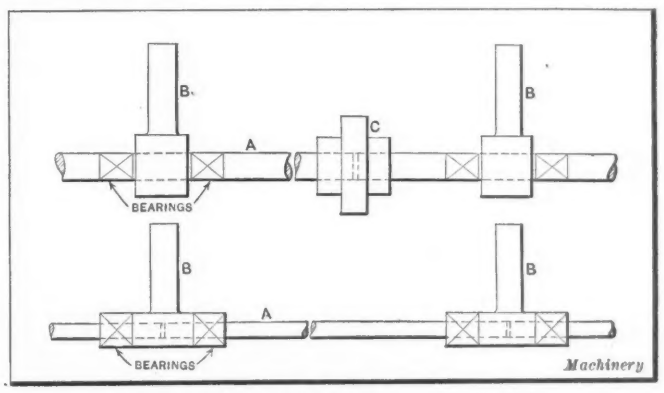

Suggested Design of Adjustable Vise

When the vise is at a convenient height, the operator is able to follow more closely each stroke of the file, without stooping over every few minutes to see if the file is hitting anywhere near the mark. With a vise that can be raised or lowered, as shown in the accompanying illustration, the work may be brought up to a convenient height for close work or lowered for heavy work, for a better leverage, as then one can get the force behind each outward stroke. Such a vise would mean a saving in time and better work. In other words, the vise should fit the man, instead of the man's fitting the vise, as is now the case.

Plainville, Conn. HARRY B. STILLMAN

## ORIGINATION VERSUS IMITATION IN DESIGN

The November number of MACHINERY contains an article entitled "Origination Versus Imitation in Design," but the following is one case where originality in design was a good




Case in which an Original Plan was Economical

dollars and cents quality. This is not a lone instance, but one of a number resulting from many years of experience.

In connection with the design of a certain water-control project, there were available the plans of two similar projects, one of which had copied very closely from the other, both good and bad points. For the new project, it would have been easy to copy from either, but original designs were made. The accompanying illustration shows some of the differences between the new and the older designs. The top view shows

the arrangement, in the older designs, of a shaft *A* with cast-steel props *B*, which are spaced about eight feet apart; the bottom view shows the shaft and props when designed after a careful study of the problem has been made.

It is necessary, in order to facilitate erection, to have the shaft in short lengths. The shaft has no torsional moment except that of overcoming the dead weight of the props when swinging them in position to hold a load and the friction caused by the dead weight of the shaft and props; this is, of course, very small. When the load is applied there is a heavy direct stress on the props. In each case, after the load is brought to bear, there is a heavy load causing bending, similar to that of a beam with the load concentrated at the center and supported at the ends. The condition is not quite so severe as a load concentrated at the center, but the assumption is on the side of safety. In the older design, the bending is taken by the shaft, which is made heavy enough to stand it; so a 4-inch shaft is used. To avoid turning it down, the shaft is made the same diameter throughout. In the later design, the bending is taken by the prop and not by the shaft, so that the shaft is submitted only to the small torsion before mentioned. As a result, a 2¼-inch shaft is sufficient. As there are two of these shafts, each over fifty feet long, there is quite a saving in the amount of steel required for shafts. The 4-inch shaft has a section modulus of 6.3, while the part of the prop taking the bending is 4½ inches in diameter with a 2¼-inch hole in it and has a section modulus of 7.8. And as the strength and stiffness of the parts are a direct function of the section modulus, it can be seen that in the later design strength has not been sacrificed to lightness.

Since the shafts must be coupled in the later designs, they are made in such lengths that the ends come in the center of the props, thus doing away with the separate couplings. As a cast-iron coupling *C* for a 4-inch shaft weighs about 290 pounds, it will be seen that another large saving is effected here. It might also be mentioned that in the later designs the parts are more easily erected, because the props do not have to be moved so far on the shaft, and the lighter weights are more easily handled in an awkward place.

In conclusion, it might be stated that if every pound of metal can be put where it will do the most good, one of the objects that should be uppermost in the mind of every designer has been accomplished; that is, to get out the best plans possible, suited to the requirements, with the least expense.

Albany, N. Y. CHARLES P. WIWEKE

## AN EMERGENCY STRAIGHTEDGE

The writer has found the tool points used in the Pratt & Whitney tool-holders for cutting U. S. S. threads to be very useful as a straightedge. As these tool points are lapped on the flat, anyone can make a selection from a bunch of six or seven and find one that checks up with a glass straightedge or test bar. Those of the finer pitch are to be preferred.

Bridgeport, Conn. JAMES MCINTYRE

## TOOLS AND BURNISHERS FOR TRUCK AXLE JOURNALS

In the illustrations are shown tools and burnishers used by a large Eastern railroad on truck axle journals of soft steel, containing about 0.40 per cent carbon, 0.55 per cent manganese and 0.05 per cent sulphur and phosphorus.

Fig. 1 shows the journal cutting tools. In order to eliminate all danger of chattering, the straight cutting face of the tool is only 3/16 inch wide. The straight tools are made in pairs, right and left, for use in double-end axle lathes. The offset tools are for use in large gap axle lathes, in which is placed an axle, with both wheels, to have the journal trued. The work speed is from 70 to 90 feet per minute, and the feed of the tools is 1/32 to 1/16 inch. If the journal being trued requires a cut over 1/16 inch deep, it is best to take two cuts, one heavy and the other light, so the burnisher will not have so much to do.

Fig. 2 shows the burnisher. The forks are all made alike so the parts can be made interchangeable when it is desired to have only one fork and several burnishing wheels. An offset fork is not recommended because it will not have a good solid bearing, on account of the tremendous pressure on the fork, but the straight fork will. Therefore it is necessary to move the working part of the roller close to the left side to get the burnisher wheel up in the fillet without having the wheel or axle rub the toolpost or carriage. The inside of the

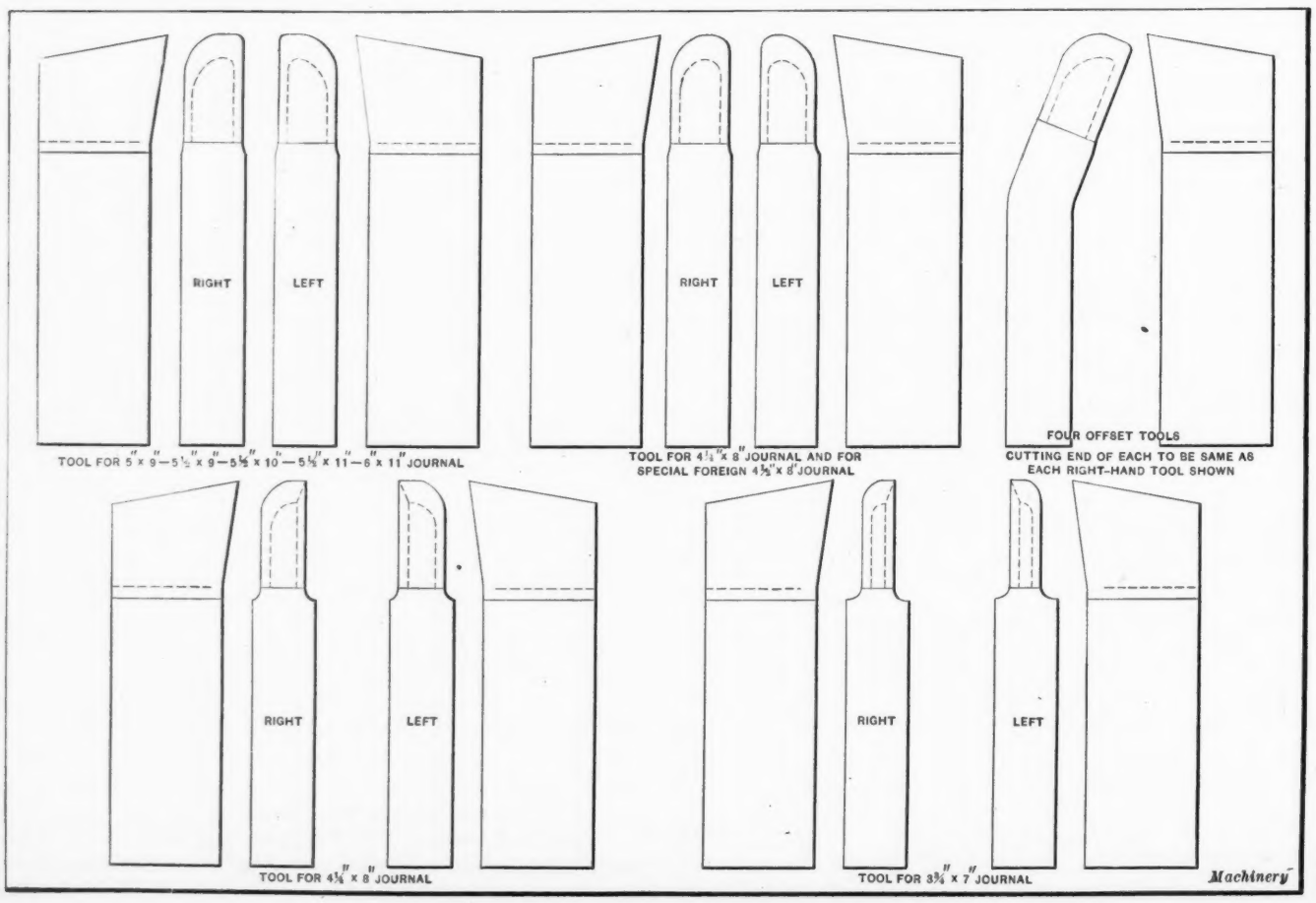

RIGHT
LEFT
TOOL FOR 5" x 9"—5½" x 9"—5½" x 10"—5½" x 11"—6" x 11" JOURNAL
RIGHT
LEFT
TOOL FOR 4¼" x 8" JOURNAL AND FOR SPECIAL FOREIGN 4⅝" x 8" JOURNAL
FOUR OFFSET TOOLS
CUTTING END OF EACH TO BE SAME AS EACH RIGHT-HAND TOOL SHOWN
RIGHT
LEFT
TOOL FOR 4¼" x 8" JOURNAL
RIGHT
LEFT
TOOL FOR 3¾" x 7" JOURNAL
Machinery

Fig. 1. Turning Tools for Journals and Wheel Seats (One-fourth Size)

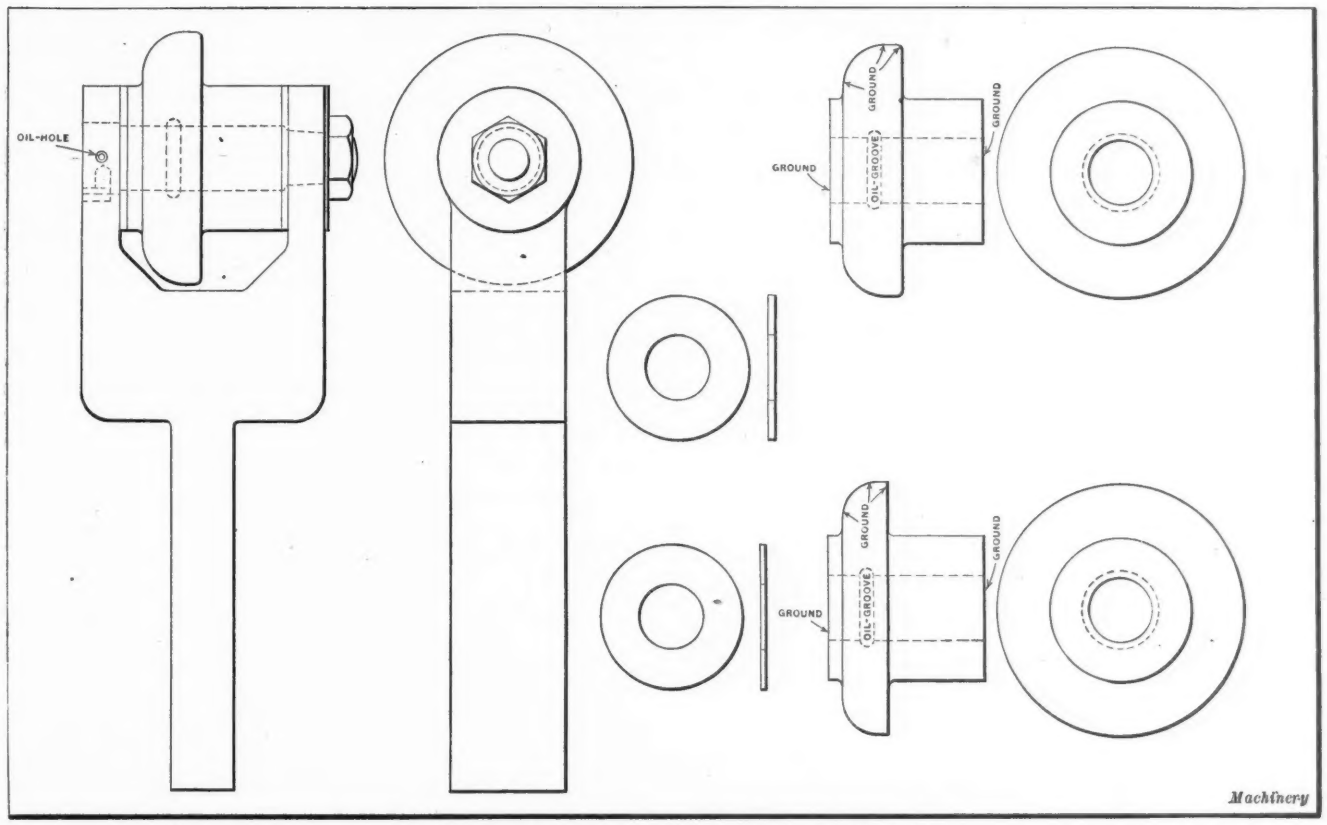



Fig. 2. Burnisher for Truck Axle Journals (One-fourth Size)

fork is finished by draw-filing. Two hardened and ground washers are placed between the fork and the tool, or burnishing wheel, so that there will be no friction. The pin and roller are hardened and ground; the roller is also ground on the inside. In making burnishers for use on gap axle lathes (for mounted axles, of course), the fork can only be used from the side nearest the tailstock of the lathe. In other words, the operator will generally lift and turn the axle after burnishing one end; as a result it will only be necessary to use the tool one way. In this case only one oil-hole is required through the fork, as shown. But when the tool is used in a double-end axle lathe, it will be used right and left, so oil-holes should be drilled from both sides in order that the tool can be oiled while running. The bottom oil-hole should always be kept plugged; also the hole in the center of the pin, which must be drilled in to the required depth to carry the oil in from the other hole. Oil-grooves are cut in the pin (Fig. 3), on the side away from the wear, and oil-retaining grooves are cut inside of the rollers. The burnishers are made of high-grade tool steel. When burnishing, the work speed is from 70 to 90 feet per minute and the feed 1/32 to 1/16 inch. The burnishers must be thoroughly lubricated at the point of contact with the work while in operation. M. K.

## "RUSSIAN" METHOD OF MULTIPLICATION

I was recently told of an odd system of multiplication which I believe is known as a "Russian" method; and a description may prove of interest to some readers of MACHINERY. Suppose it is required to multiply 206 by 37: Make up columns and head them "multiplicand" and "multiplier," respectively. Start by dividing the multiplier, *i. e.*, 37, by 2 and disregard the remainder. Write the quotient as the second number in the column headed "multiplier" and then divide the quotient by 2 to obtain the third number in this column. Proceed in the same manner until 1 is obtained as the final quotient.

To obtain figures in the second column in which the multiplicand is the first number, proceed by multiplying the multiplicand by 2 to obtain the second number; then multiply this product by 2 to obtain the third number in this column, and so on until there are the same number of rows in each column.

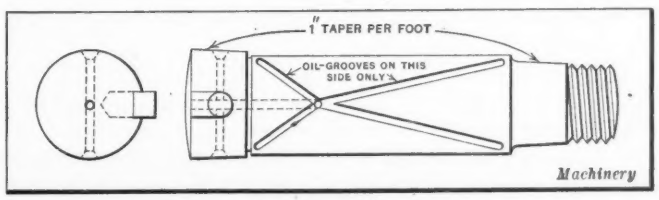



Fig. 3. Detail of Burnishing Roller Pin

Beginning at the top, cancel each corresponding row of figures that is divisible by 2; and add the remaining figures in the "multiplicand" column, which gives the required product of the original multiplicand and multiplier.

The method will be better understood by carrying through the problem as follows:

| Multiplier | Multiplicand | |
|---|---|---|
| 37 | 206 | 206 |
| 18 | 412 | |
| 9 | 824 | 824 |
| 4 | 1648 | |
| 2 | 3296 | |
| 1 | 6592 | 6592 |
| | | 7622 |

As a check on the preceding, we have: $206 \times 37 = 7622$.

Denver, Colo. STANLEY EDWARDS

## A PROTECTOR AGAINST BLOTTING

There is nothing that fully expresses the feelings of a draftsman who inadvertently blots or smudges the still wet ink of a carefully made drawing, particularly where the design is of an intricate character or where many parts come together. Of course some draftsmen can, by reason of their steady hands and long training, draw ink lines in the midst of a complicated mass of lines without touching the drawing sheet, but such a process is nerve racking and is not always successful.

The blotting and smudging can easily be avoided by the use of a curved hand rest. This may be made by cutting a barrel stave to a suitable width, preferably about two inches, and to a length of about fourteen inches. It is then sandpapered and its edges smoothed; if desired, it may be shellacked or varnished. In use, the device is placed over the drawing so that the ends of the stave will span the work, thus forming a support for the draftsman's hand. The stave will be above the drawing paper, except at its ends, and will keep the hands away from the sheet and thus prevent blotting and smudging the drawing.

A. P. CONNOR

Washington, D. C.

# INTERNAL HELICAL GEARING[1]

NORMAL PITCH AND CIRCULAR PITCH—CURVATURE OF TEETH—INTERFERENCE—PROPORTIONS—STRENGTH—MACHINING

BY REGINALD TRAUTSCHOLD[2]

THE requirements of smoothness and silence in operation, long life, and high efficiency for high-speed parallel gear transmission, which in the case of externally meshing gears are best secured through the gradual engagement of spiral teeth, are likewise met by internal helical gearing. In addition to these decided advantages, internal helical gearing discounts certain of the drawbacks common to internal spur gearing. That is, the relative advantage of cutting the teeth at an angle to the axis of the gear is greater in the case of internal helical gearing than in external helical gearing.

A typical lay-out of internal helical gearing is shown in Fig. 1. From this it is plain that the tooth action is identical with that of externally meshing helical gears and the arrangement of the teeth is similar, with the exception that for internal gearing the spiral angles of both gear and pinion are of the same hand, while for externally meshing gears the hands of the respective spiral angles are opposite—one is right and the other left. This is because, in internal gearing, the direction of rotation of both gear and pinion is the same, while in the more common type of gearing the pinion revolves in one direction and the gear in the opposite.

### Peculiarities of Helical Gearing

Helical gearing has two circular pitches, the normal pitch, which is the shortest distance between centers of consecutive teeth measured on the normal pitch curve, and the circular pitch, which is the shortest distance between centers of consecutive teeth measured on the pitch circle in the plane of the gear, that is, in a plane at right angles to the axis of the gear, as in the case of ordinary spur gearing. This double pitch is responsible in large part for the smoothness and silence of operation. Besides, the obliquity of the teeth produces gradual engagement and avoids shock of impact, for the effective pressure angle of the teeth—the pressure angle in the plane of the gear—is greater than the normal pressure angle governing the normal tooth section. For instance, the effective pressure angle of helical gears with a 14½-degree normal profile pressure angle is greater than 14½ degrees, the increase depending upon the angle of spiral, or the angle measuring the obliquity of the teeth. An increased pressure angle always tends toward increased smoothness in operation.

An increased pressure angle also reduces interference; and, as interference is much more marked in internal gearing than in gears meshing externally, the decrease is more marked in internal gearing and discounts in helical gearing that which has proved one of the most serious drawbacks to internal spur gearing of the involute system. Theoretically, at least, the spiral angle of internal helical gearing could be made sufficiently great to avoid all interference, irrespective of the number of teeth in the pinion and the speed ratio of the gears, making the involute system as adaptable as the cycloidal system for internal helical gearing. In practice, however, it is seldom advisable to make the spiral angle greater than about 20 degrees, on account of the axial thrust created by the obliquity of the teeth. With a normal pressure angle of 14½ degrees and a spiral angle of 20 degrees, the effective pressure angle will be 15 degrees, 27 minutes. This increase in pressure angle will not, in itself, be sufficient to avoid interference in gear combinations of usual speed ratios, so that correction for interference by rounding off the corners, as for internal spur gear combinations of the involute system, is still necessary. But the amount to be removed from the corner of the internal helical gear teeth is not as great as in the case of similar internal spur gear teeth.

### Normal Pitch Ellipse

The effect of arranging the teeth obliquely across the face of the gear is to increase the pitch diameter, the normal section and pitch remaining the same, owing to the circular pitch being greater than the normal pitch. The normal pitch of a helical gear corresponds to the circular pitch of a spur gear. Referring to Fig. 2, it is evident that the normal pitch curve must be a section of an ellipse (an oblique section of a cylinder being elliptic in outline), the conjugate axis of which is equal to the pitch diameter of the helical gear, and the major axis equal to the pitch diameter divided by the cosine of the spiral angle. Actually, no such normal pitch ellipse exists, for there are not enough teeth in the gear to circumscribe such a curve. Nevertheless, it is a short section of the flattest part of the ellipse, the section straddling the conjugate axis, which controls the proportioning of the teeth. This normal pitch arc, or

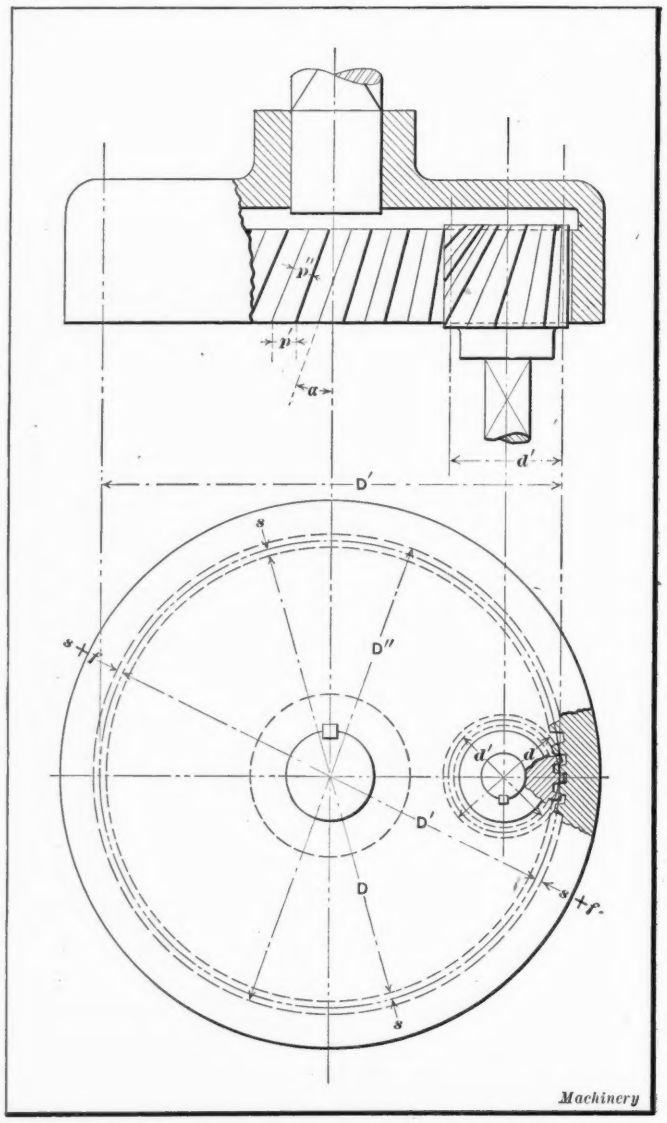



Fig. 1. Lay-out of Internal Helical Gearing with a Speed Ratio of 4:1

curve, is approximately an arc of a radius equal to the major axis of the ellipse minus one-half its conjugate axis. The normal section of a helical gear tooth is controlled then not by the pitch diameter directly, but by a radius equal to the pitch diameter of the gear divided by the cosine of the spiral angle minus one-half the pitch diameter.

### Curvature of Helical Gear Teeth

Helical gear teeth, being of constant depth, are also slightly curved in their length. As in the case of the normal pitch curve, a close approximation, as the radius of curvature is practically accurate, for the true curvature is the flat section of an ellipse; see Fig. 3. The conjugate axis of the ellipse is

[1] For previous information on internal gearing, see "Internal Spur Gearing" in the January, 1917, number of MACHINERY.

[2] Address: 39 Charles St., New York City.

again the pitch diameter of the helical gear, but the major axis is equal to the pitch diameter divided by the sine of the spiral angle. The curvature of the tooth, the section of the ellipse straddling the conjugate axis, is then approximately the arc of a radius equal to the difference between the major axis of the ellipse and one-half its conjugate axis. That is, the radius of tooth curvature equals the pitch diameter of the gear divided by the sine of the spiral angle minus one-half the pitch diameter. For external helical gears, the tooth curvature is convex, and for internal helical gears it is concave.

### Interference of Internal Helical Gear Teeth

The interference circle, locating the point on the teeth at which interference commences, is not fixed for internal helical gears as it is for internal spur gears. In the latter type of gear, it is located midway between the pitch and base circles for 14½-degree involute teeth. For internal helical gear teeth of normal 14½-degree involute standard, the interference circle is relatively smaller and lies nearer the base circle. Two factors govern the point at which interference commences: the pressure angle and the number of teeth. Both of these factors are dependent on the angle of spiral, the beginning of the point of interference being the same whether the normal section of the tooth is considered or the section in the plane of the gear.

Although the ordinary pressure angle of the normal tooth section of an internal helical gear is 14½ degrees, the normal pitch arc that controls the position of the teeth is greater than the pitch radius of an internal spur gear of the same number of teeth, pitch, and pressure angle. In other words, comparison may be made with an internal spur gear combination of greater speed ratio. The effect is the same as slightly decreasing the curvature of a gear section; the point of interference is brought nearer the top of the tooth for the particular speed ratio. The effective pressure angle, considering the tooth section in the gear plane, is greater than 14½ degrees so that the point at which interference commences must be nearer the top of the tooth. A fixed relationship exists between the increased pressure angle, the normal pitch arc radius, and the number of teeth in the gear and pinion.

With the more advantageous location of the point at which interference commences in internal helical gears of standard normal pitch, there is a corresponding reduction in the amount of the corner of the tooth that has to be removed to avoid interference. The dedendum cutting radius for the normal tooth section is obtained from the normal pitch arc radius. The proportion of this latter radius that is taken is the same as that of the pitch radius of an internal spur gear taken for the dedendum cutting radius of the spur gear, so that the actual dedendum cutting radius for helical internal gears is the larger for a given pitch (normal), and less of the tooth corner is removed. In the plane of the gear, the dedendum cutting radius bears the same relationship to the pitch diameter as in the case of internal spur gears, although the effective pressure angle is greater than the pressure angle would be in the case of the internal spur gear—the circular pitch of the spur gear corresponding to the normal pitch of the helical gear.

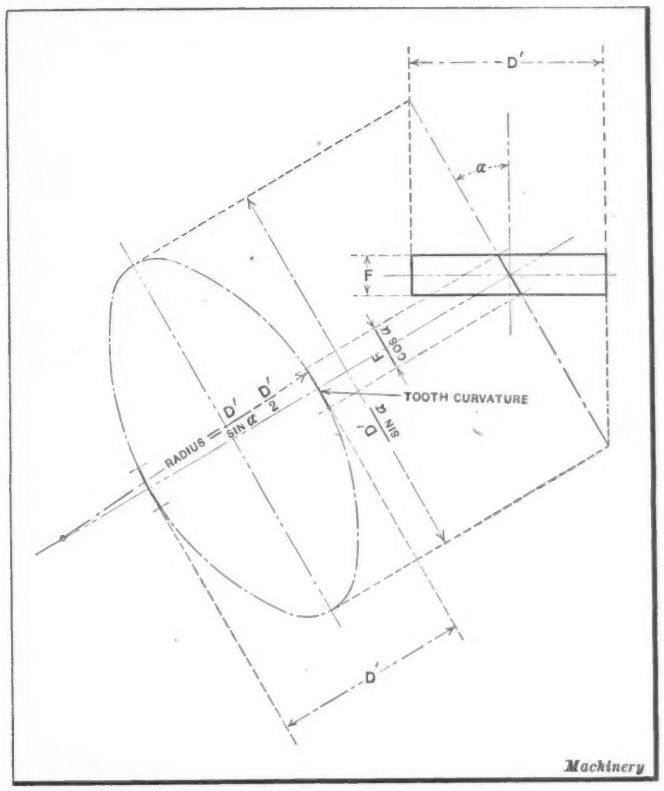



Fig. 3. Tooth Curvature Arc of Helical Gears

Formulas for the calculation of both the dedendum cutting radius (normal) and the effective cutting radius will be derived, as well as for ascertaining the correction arc radius and the effective correction curve radius from which the respective dedendum cutting arcs are struck, but formulas for locating the interference curves will be omitted, as they are of little practical value and are likely to lead to confusion. In laying out internal helical gear teeth, the dedendum cutting arc is made tangent to the tooth profile—the point of tangency being actually on the interference curve—and is struck about a center located on the correction curve.

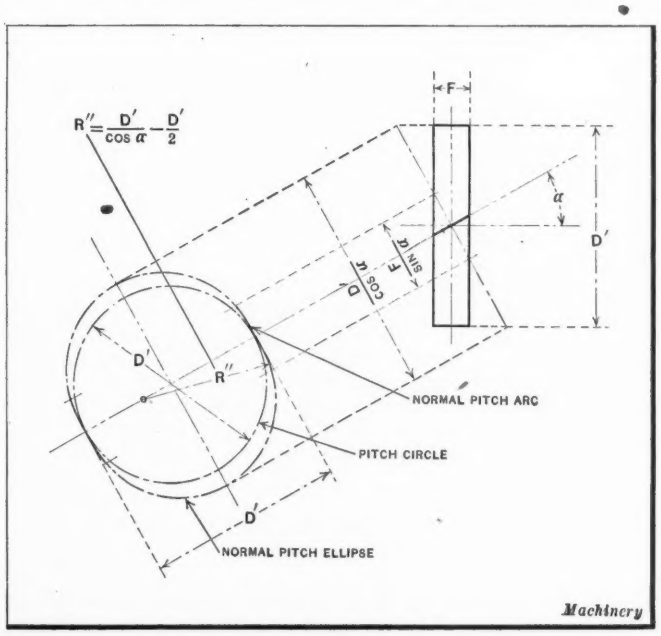



Fig. 2. Normal Pitch Arc Radius of Helical Gears

### Proportions of Internal Helical Gear Teeth

Fig. 4 depicts cross-sections of internal helical gear teeth, viewed first on a normal plane and second on the plane of the gear. Although the spiral angle of the gear illustrated is less than 20 degrees, there is quite an appreciable difference in the proportions of the teeth viewed from the different angles. The normal tooth section is similar to that of an internal spur gear of the same pitch and pressure angle but with a considerably greater number of teeth than are actually on the internal helical gear. The effective tooth section, on the other hand, is similar to that of an internal spur gear of the same number of teeth, but of a greater pressure angle and larger pitch.

The relative location of the base-curve arc and the pitch-curve arc is not materially affected in the two views, for the radius of this curve depends on the respective pitch arc radii and on the cosine of the respective pressure angles. As the radius and angle increase, the cosine of the pressure angle decreases, so there is little relative difference in the product of the respective radii and the cosine of their corresponding pressure angles. On the other hand, the relative location of the correction-curve arc, in respect to the pitch-curve arc, is quite appreciably different in the two views. This is due to the fact that the correction-curve arc is controlled by the pitch-curve arcs and the reciprocal of the cosine of the pressure angle. When the pitch-curve radius is the greater (proportionally) and the pressure angle correspondingly increased, the cosine of

the angle is smaller and the increase in the quotient of the pitch-curve radius divided by the cosine of the pressure angle is quite marked.

### Strength of Helical Gear Teeth

The effective thickness of helical gear teeth bears the same relationship to the normal thickness of the tooth as does the pitch diameter of helical gears to the major axis of the imaginary normal pitch ellipse; that is, it equals the normal thickness of the tooth divided by the cosine of the spiral angle. Furthermore, more than one set of teeth in a gear combination, the number depending on the angle of spiral and the pitch of the gear, are always in contact and transmitting power at the same time. The result is that the teeth of helical gears are practically indestructible from fracture in operation and a very much finer normal pitch can be employed than could be used with safety in spur gearing transmitting the same amount of power.

Instead of employing a finer pitch, the face of the helical gear could be decreased, but this would necessitate an increase in the spiral angle in order to secure the advantage of the same number of teeth in contact at one time, resulting in increased axial thrust. As axial thrust serves no useful purpose and is difficult to control, unless double helical gears of the herringbone type can be employed, an increased spiral angle should be avoided. The use of a finer pitch on account of the increased effective strength of helical gear teeth is then decidedly preferable to a decrease in the width of the gear for the same reason.

### Notation for Internal Helical Gearing

| | Gear | Pinion |
|---|---|---|
| Angle of spiral | $\alpha$ | $\alpha$ |
| Number of teeth | $N$ | $n$ |
| Diametral pitch | $p$ | $p$ |
| Circular pitch | $p'$ | $p'$ |
| Normal pitch | $p''$ | $p''$ |
| Pitch diameter | $D'$ | $d'$ |
| Normal pitch arc radius | $R''$ | $r''$ |
| Outside diameter | | $d$ |
| Inside diameter | $D$ | |
| Dedendum diameter | $D''$ | |
| Addendum | $s$ | $s$ |
| Clearance | $f$ | $f$ |
| Dedendum | $s+f$ | $s+f$ |
| Whole depth of tooth | $W$ | $W$ |
| Thickness of tooth (normal) | $t$ | $t$ |
| Lead | $L$ | $l$ |
| Pressure angle | $\beta$ | $\beta$ |
| Effective pressure angle | $\delta$ | $\delta$ |
| Base arc radius | $B$ | |
| Effective base arc radius | $B_e$ | |
| Correction arc radius | $C$ | |
| Effective correction arc radius | $C_e$ | |
| Dedendum cutting radius | $b'$ | |
| Effective dedendum cutting radius | $b_e'$ | |
| Addendum cutting radius | $c'$ | |
| Effective addendum cutting radius | $c_e'$ | |

| | Pair of Gears |
|---|---|
| Speed ratio | $V$ |
| Center distance | $X$ |

### Formulas for Internal Helical Gearing

$$D' = \frac{2VX}{V-1} = Np'0.3183 \quad (1) \qquad d' = \frac{2X}{V-1} = np'0.3183 \quad (1a)$$

$$N = \frac{3.1416D'}{p'} = nV \quad (2) \qquad n = \frac{3.1416d'}{p'} = \frac{N}{V} \quad (2a)$$

$$\cos\alpha = \frac{p''}{p'} \quad (3) \qquad p' = \frac{p''}{\cos\alpha} \quad (4)$$

$$p'' = p'\cos\alpha = \frac{3.1416}{p} \quad (5) \qquad p = \frac{3.1416}{p''} \quad (6)$$

$$d = d' + p''\,0.6366 \quad (7) \qquad D = D' - p''\,0.6366 \quad (8)$$

$$D'' = D' + p''\,0.7366 \quad (9) \qquad s = p''\,0.3183 \quad (10)$$

$$f = p''\,0.05 \quad (11) \qquad s+f = p''\,0.3683 \quad (12)$$

$$W = p''\,0.6866 \quad (13) \qquad t = p''\,0.5 \quad (14)$$

$$L = 3.1416\,D'\cot\alpha \quad (15) \qquad l = 3.1416d'\cot\alpha \quad (15a)$$

$$R'' = \frac{D'}{\cos\alpha} - \frac{D'}{2} \quad (16) \qquad r'' = \frac{d'}{\cos\alpha} - \frac{d'}{2} \quad (16a)$$

$$B = R''\cos\beta \quad (17) \qquad C = \frac{R''}{\cos\beta} \quad (18)$$

$$b' = 0.25R'' \quad (19) \qquad c' = \sqrt{(0.25R'')^2 + (0.25r'')^2} \quad (20)$$

$$\sin\delta = \frac{\sin\beta}{\cos\alpha} = \frac{0.25038}{\cos\alpha} \quad (21) \qquad B_e = 0.5D'\cos\delta \quad (22)$$

$$C_e = \frac{D'}{2\cos\delta} \quad (23) \qquad b_e' = 0.125D' \quad (24)$$

$$c_e' = \sqrt{(0.125D')^2 + (0.125d')^2} \quad (25)$$

$$V = \frac{N}{n} = \frac{D'}{d'} = \frac{R''}{r''} \quad (A) \qquad X = 0.5\,(D' - d') \quad (B)$$

*Example 1.*—Required: An internal helical gear combination cut normally with a 4-pitch involute cutter; 76 teeth in gear, 19 teeth in pinion; center distance, 7½ inches. That is, $p = 4$, $V = \frac{76}{19} = 4$, $X = 7.5$ inches

$$D' = \frac{2 \times 4 \times 7.5}{4-1} = 20 \text{ inches} \quad (1)$$

$$d' = \frac{2 \times 7.5}{4-1} = 5 \text{ inches} \quad (1a)$$

$$p' = \frac{3.1416 \times 20}{76} = 0.8267 \text{ inch} \quad (4)$$

$$p'' = \frac{3.1416}{4} = 0.7854 \text{ inch} \quad (5)$$

$$\cos\alpha = \frac{0.7854}{0.8267} = 0.95 \quad (3) \qquad \alpha = 18 \text{ degrees, } 11 \text{ minutes}$$

$$d = 5 + 0.7854 \times 0.6366 = 5.5 \text{ inches} \quad (7)$$

$$D = 20 - 0.7854 \times 0.6366 = 19.5 \text{ inches} \quad (8)$$

$$D'' = 20 + 0.7854 \times 0.7366 = 20.5785 \text{ inches} \quad (9)$$

$$s = 0.7854 \times 0.3183 = 0.25 \text{ inch} \quad (10)$$

$$f = 0.7854 \times 0.05 = 0.0393 \text{ inch} \quad (11)$$

$$s + f = 0.7854 \times 0.3683 = 0.2893 \text{ inch} \quad (12)$$

$$W = 0.7854 \times 0.6866 = 0.5393 \text{ inch} \quad (13)$$

$$t = 0.7854 \times 0.5 = 0.3927 \text{ inch} \quad (14)$$

$$L = 3.1416 \times 20 \times 3.0445 = 191.292 \text{ inches} \quad (15)$$

$$l = 3.1416 \times 5 \times 3.0445 = 47.823 \text{ inches} \quad (15a)$$

$$R'' = \frac{20}{0.95} - \frac{20}{2} = 11.0526 \text{ inches} \quad (16)$$

$$r'' = \frac{5}{0.95} - \frac{5}{2} = 2.7632 \text{ inches} \quad (16a)$$

$$B = 11.0526 \times 0.96815 = 10.7006 \text{ inches} \quad (17)$$

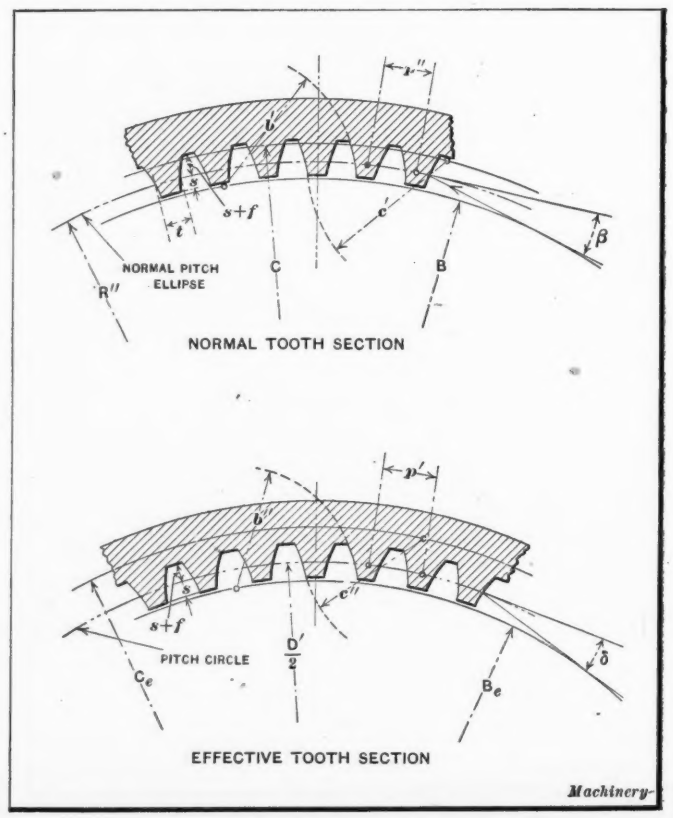



Fig. 4. Internal Helical Gear Tooth Proportions

$$C = \frac{11.0526}{0.96815} = 11.4162 \text{ inches} \quad (18)$$

$$b' = 0.25 \times 11.0526 = 2.7632 \text{ inches} \quad (19)$$

$$c' = \sqrt{(0.25 \times 11.0526)^2 + (0.25 \times 2.7632)^2} = 2.8481 \text{ inches} \quad (20)$$

$$\sin \delta = \frac{0.25038}{0.95} = 0.26356 \quad (21)$$

$$\delta = 15 \text{ degrees, } 17 \text{ minutes}$$

$$B_e = 0.5 \times 20 \times 0.96463 = 9.6463 \text{ inches} \quad (22)$$

$$C_e = \frac{20}{2 \times 0.96463} = 10.3667 \text{ inches} \quad (23)$$

$$b_e' = 0.125 \times 20 = 2.50 \text{ inches} \quad (24)$$

$$c_e' = \sqrt{(0.125 \times 20)^2 + (0.125 \times 5)^2} = 2.5769 \text{ inches} \quad (25)$$

*Example 2.*—Required: An internal helical gear combination to replace an internal spur gear set of 60 and 15 teeth, respectively, 3 pitch, 7½ inches between centers. The speed ratio is to remain the same and the helical gears are to be cut with the same normal pitch. That is, $p = 3$, $V = \frac{60}{15} = 4$, $X = 7.5$ inches.

$$D' = \frac{2 \times 4 \times 7.5}{4 - 1} = 20 \text{ inches} \quad (1)$$

$$d' = \frac{2 \times 7.5}{4 - 1} = 5 \text{ inches} \quad (1a)$$

$N = 56$ (Assumed) $n = 14$ (Assumed)

$$p' = \frac{3.1416 \times 20}{56} = 1.122 \text{ inch} \quad (4)$$

$$p'' = \frac{3.1416}{3} = 1.0472 \text{ inch} \quad (5)$$

$$\cos a = \frac{1.0472}{1.122} = 0.93333 \quad (3)$$

$$a = 21 \text{ degrees, } 2 \text{ minutes}$$

$$d = 5 + 1.0472 \times 0.6366 = 5.6666 \text{ inches} \quad (7)$$

$$D = 20 - 1.0472 \times 0.6366 = 19.3334 \text{ inches} \quad (8)$$

$$D'' = 20 + 1.0472 \times 0.7366 = 20.7714 \text{ inches} \quad (9)$$

$$s = 1.0472 \times 0.3183 = 0.3333 \text{ inch} \quad (10)$$

$$f = 1.0472 \times 0.05 = 0.0524 \text{ inch} \quad (11)$$

$$s + f = 1.0472 \times 0.3683 = 0.3857 \text{ inch} \quad (12)$$

$$W = 1.0472 \times 0.6866 = 0.72 \text{ inch} \quad (13)$$

$$t = 1.0472 \times 0.5 = 0.5236 \text{ inch} \quad (14)$$

$$L = 3.1416 \times 20 \times 2.6006 = 163.4008 \text{ inches} \quad (15)$$

$$l = 3.1416 \times 5 \times 2.6006 = 40.8502 \text{ inches} \quad (15a)$$

$$R'' = \frac{20}{0.9333} - \frac{20}{2} = 11.4287 \text{ inches} \quad (16)$$

$$r'' = \frac{5}{0.9333} - \frac{5}{2} = 2.8573 \text{ inches} \quad (16a)$$

$$B = 11.4287 \times 0.96815 = 11.0647 \text{ inches} \quad (17)$$

$$C = \frac{11.4287}{0.96815} = 11.8046 \text{ inches} \quad (18)$$

$$b' = 0.25 \times 11.4287 = 2.8572 \text{ inches} \quad (19)$$

$$c' = \sqrt{(0.25 \times 11.4287)^2 + (0.25 \times 2.8573)^2} = 2.9449 \text{ inches} \quad (20)$$

$$\sin \delta = \frac{0.25038}{0.9333} = 0.26827 \quad (21)$$

$$\delta = 15 \text{ degrees, } 34 \text{ minutes}$$

$$B_e = 0.5 \times 20 \times 0.96332 = 9.6332 \text{ inches} \quad (22)$$

$$C_e = \frac{20}{2 \times 0.96332} = 10.3807 \text{ inches} \quad (23)$$

$$b_e' = 0.125 \times 20 = 2.5 \text{ inches} \quad (24)$$

$$c_e' = \sqrt{(0.125 \times 20)^2 + (0.125 \times 5)^2} = 2.5769 \text{ inches} \quad (25)$$

### Discussion of Formulas

The double pitch peculiarity of helical gears complicates the derivation of convenient formulas for the calculations involved in the design of helical gearing, the pitch diameters and the number of teeth being controlled by the circular pitch and all other diameters affected by the normal pitch, from which the tooth proportions are also figured. The relationship existing between the normal pitch and the measurements figured from it is similar to the relationship of the circular pitch of spur gears to their similar measurements.

As practically any pitch diameter of gear, for a given number of teeth of certain pitch, can be secured by varying the spiral angle of helical gear combinations, it is customary to consider the distance between the pinion and gear shafts as fixed and to proportion the pitch diameters accordingly. In the case of internal helical gearing, twice the center distance divided by the speed ratio minus 1 gives the pitch diameter of the pinion and this multiplied by the speed ratio gives the pitch diameter of the gear.

The pitch circle diameter divided by the number of teeth in an internal helical gear gives its circular pitch, and its normal pitch divided by the circular pitch gives the cosine of the spiral angle. The outside diameter of the pinion, inside diameter of the internal gear, and all tooth proportions are then calculated from the normal pitch by formulas similar to the corresponding formulas for internal spur gearing, the pitch diameter having first been proportioned according to the circular pitch.

The normal pitch arc radius is the approximate radius of the flat section of the imaginary normal pitch ellipse and is found by dividing the pitch diameter of the gear by the cosine of the spiral angle and subtracting from the quotient one-half the pitch diameter. From the normal pitch arc radius are figured the base arc radius, correction arc radius, dedendum cutting radius, and addendum cutting radius for the internal helical gear; all as corresponding dimensions are figured for internal spur gears.

The spiral lead is the distance covered by the thread in one complete revolution of the pitch circle and is equal to the pitch circumference multiplied by the cotangent of the spiral angle.

The sine of the effective pressure angle is found by dividing the sine of the pressure angle (normal) by the cosine of the spiral angle. The cosine of the effective pressure angle is employed for ascertaining the effective base arc radius and the effective correction arc radius in a similar manner to that used in calculating the corresponding dimensions for internal spur gears, the pitch diameter of the internal helical gear being the other governing factor.

The effective dedendum and addendum cutting radii are also customarily figured from the pitch diameters, just as the corresponding normal radii are calculated. A slight inaccuracy exists in such practice, for if the tooth profile curves are arcs of circles in planes normal to the tooth axis they cannot also be arcs of circles in an oblique plane, but must be arcs of ellipses. The error is slight, however, and carries practically little weight, but slight wear being required to rectify any slight interference which may exist.

### Machining Internal Helical Gears

Three general methods of cutting internal helical gear teeth may be employed: Using rotary cutters in special milling machines; planing the teeth; and employing end-mill cutters. The milling method is naturally the most rapid and is the one generally employed if the gears are to be made in quantities. In this process, the gear blank is made to revolve during the cutting of the teeth, the plane of the cutting tool—rotary mill—being maintained normal to the plane of the gear. This method is feasible only for gears of comparatively slight obliquity (spiral angle), as the cutter must clear itself as it traverses the face of the gear. The practical spiral angle is also limited and the diameter of the gear must be comparatively large in order to provide accommodation within the confines of the blank for the rotary mill and the spindle of the milling machine. The rotating speed of the gear blank is made proportional to the spiral lead of the gear teeth and the feed accommodated accordingly. The cutter is proportioned to conform to the effective tooth section, so that a special cutter is required for each gear of differing obliquity, if accuracy is essential. When the involute form of tooth can be deviated from, the same cutter may be employed in machining gears of differing spiral angle, provided the cutter used for the mating pinion is proportioned accordingly.

When planing the teeth of internal helical gears the cutting tool may be made to conform to the effective tooth section of the gear and the gear blank revolved during the cutting operation, as in the milling process. In another planing method, the gear blank is held stationary, except for the necessary indexing from tooth to tooth, and the cutter is made to conform to the normal tooth section. The plane of the cutting tool is inclined to the plane of the gear at an angle conforming to the obliquity of the gear teeth and the tool is guided by suitable templets in a path following the slight longitudinal curvature of the teeth; the radius of curvature of the "former" is made proportional to the pitch diameter of the gear divided by the sine of the spiral angle minus one-half the pitch diameter.

Machining helical gear teeth with the Fellows gear shaper constitutes a third planing method. For such process, the pinion cutter is proportioned to conform to the normal tooth section, for if machined in the plane of the axis of the gear the cutter could not properly clear itself. Furthermore, following the tooth space permits the standard pinion cutter to be employed. The gear blank is mounted on the work-spindle inclined at the angle of spiral, so that the normal tooth axis, the obliquity of the gear teeth, coincides with the reciprocating path of the pinion cutter when the cutter is normal to to the tooth space section. The gear blank is revolved slowly in its inclined plane at a speed proportional to the spiral lead of the gear, the cutting pinion tool reciprocating rapidly across the face of the gear. Each tooth space is finished on the completion of each revolution of the pinion cutter.

This method of machining helical gear teeth is exceedingly accurate and efficient, for the teeth are generated by a true involute cutter, just as if the gear and mating pinion were rolled together and the teeth molded. The longitudinal curvature of the tooth is automatically taken care of by the cutter following the cylindrical outline of the gear face. The path of the cutter is a true ellipse in reference to the axis of the gear blank and at the same time is in a plane normal to the tooth section on account of the slow revolution of the gear blank while the cutter traverses the face of the gear.

On the commencement of each cutting stroke and upon the completion of each stroke, the distance from the momentary contact of cutter and gear blank to the center of the work-spindle is at a minimum and at the center of the gear face is at a maximum, giving the true concave curvature of the internal helical gear tooth, the section of an ellipse straddling the normal pitch diameter of the gear and its conjugate axis.

The cutting of internal helical gear teeth with end-mills does not usually prove as satisfactory as milling with rotary cutters, on account of the relatively small tool surface over which the unavoidable tool wear has to be distributed. The method is of interest, however, as by it double helical internal gears of the herringbone variety can be most easily machined. A central groove, or recess, slightly wider than the diameter of the mill at the top of the teeth is cut about the inside of the gear, a shade deeper than the whole depth of the tooth. The oblique teeth on the outer edge of the gear are then cut in a similar manner to that employed for cutting internal helical gear teeth with rotary cutters (the milling method), the end-mill being proportioned to conform to the effective tooth section and the gear blank fed normally to the mill and revolved at the proper speed during the cutting operation. The teeth on the outer half of the gear face, terminating at the central groove, are finished at one setting of the machine, after which the rotation of the gear blank is simply reversed and the other teeth, those extending from the central groove to the inside edge of the gear face, are finished in like manner.

Another advantage secured by the employment of end-mills for machining internal helical gears is the more compact design of gear which can be utilized, as compact, in fact, as for gears with planed teeth. The end-mill and the planing tool require but little clearance between the inner edge of the gear face and the web of the gear blank, while rotary cutters require considerably more space in which to clear themselves.

### Internal Helical Gears of Low Ratio

Although it is possible to secure lower speed ratios with internal helical gears having standard 14½-degree involute teeth (normal section) than is possible with internal spur gears with similar tooth profiles (owing to the increase in effective pressure angle due to the spiral angle), it is not always possible to use a speed ratio as large as the minimum limit for the particular degree of helical tooth obliquity. At other times the obliquity of the teeth is limited by the ability of caring for the axial thrust to such an extent that the desired speed ratio cannot be obtained on account of excessive tooth interference. In such cases, the cycloidal system of gear teeth is usually resorted to, as in the case of internal spur gears.

### Internal Helical Gears with Cycloidal Teeth

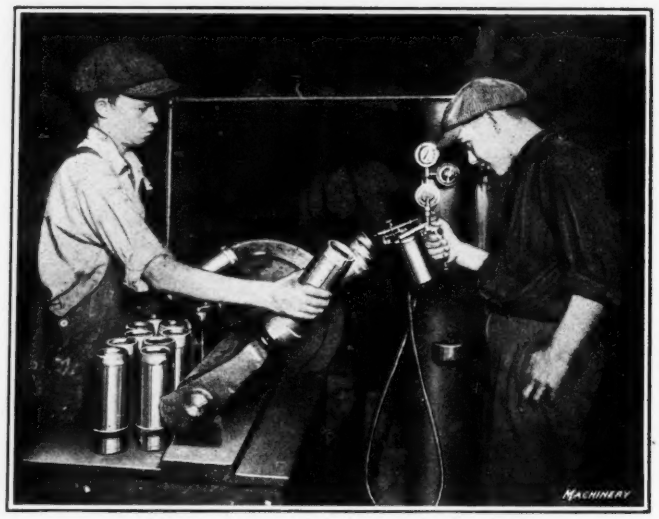
The formulas which have been presented for the solution of internal helical gears of the involute system also apply to similar gears with cycloidal teeth, the formulas for the dedendum and addendum cutting radii and also those for ascertaining the radii of correction arcs being, of course, neglected, as avoidance of interference does not have to be provided for in one instance, and in the other the curve of the tooth profile in cycloidal gearing differs from that in involute gearing.

The diameter of the generating circle for helical gear teeth cut to the cycloidal standard is customarily taken as equal to the radius of the pitch circle of a spur gear of either twelve or fifteen teeth of a circular pitch equal to the normal pitch of the gear to be developed, provided that the gear for which the generating circle is chosen has as many or more teeth.

* * *

## ROTARY SHELL PAINTING MACHINE

The accompanying illustration shows a machine for rotating shells while they are being sprayed inside, several of which have been designed and built by the Vermont Farm Machine Co., Bellows Falls, Vt., for its own use. This machine has a capacity for holding four shells at one time. It consists simply of a horizontal shaft carrying four bevel gears which engage with the bevel gears on the four work-holding spindles,




Rotating Machine for painting Interiors of Shells

causing them to rotate. On the end of the shaft is a wooden pulley through which power is transmitted by a small round belt from a motor underneath the machine. The device for holding the shells as they rotate consists of a loose fitting cup, in which the shells are centered, being held by gravity. The machine can be inclined at any desired angle, but 45 degrees seems to be most desirable. In operation, two boys stand in the position indicated. One replaces the completed shells by new ones, while the other sprays the interiors. The machine runs at about 30 revolutions per minute. The two boys can paint about 4000 shells per day of ten hours. V. B.

* * *

Clean castings may be made from scrap brass and bronze by placing a handful of plaster-of-paris in the bottom of the crucible before putting in the metal. Of course, all iron should be removed from the scrap by passing it through magnetizing machines, if finely divided, or by hand. As the plaster-of-paris rises through the molten metal, it carries off the free dirt and most of the oxides.

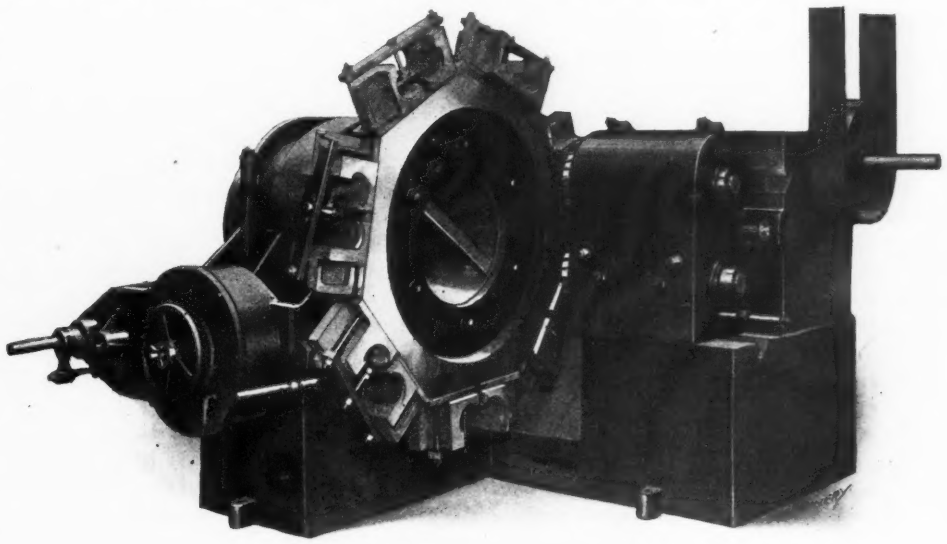
# NEW MACHINERY AND TOOLS

THE COMPLETE MONTHLY RECORD OF NEW AMERICAN METAL-WORKING MACHINERY

## DAVIS MULTIPLE-SPINDLE DUPLEX MILLING MACHINE

A duplex milling machine of the rotary continuous-milling type has been designed by the Davis Mfg. Co., 57th Ave. and Mitchell St., Milwaukee, Wis. This is a special machine intended for milling large quantities of duplicate castings or forgings. The work-holding table revolves in a vertical plane, and the parts to be milled are attached to its periphery. This table has a continuous feeding movement, and as each successive part comes around to the milling position, it passes first between a pair of roughing cutters and then between a pair of finishing cutters.

The machine is driven by a single-belt pulley which may be seen at the right-hand side of the illustration. Motion is transmitted from the belt pulley shaft to a second shaft within the housing through reduction gearing having a ratio of 20 to 1. On the second shaft wide gears having a face width of 10 inches are mounted, and these drive the upper and lower cutter-spindles. The cutter-spindle housings are adjustable parallel to the axis of the work-table spindle, for varying the distance between the milling cutters. This adjustment enables the machine to be used for milling pieces varying from 1 inch to 16½ inches in width.



Davis Duplex Multiple-spindle Milling Machine of Continuous-milling Type

The work-table is bolted to the flange of a large tubular sleeve. The large bearing for this sleeve is formed on a slide or carriage that is given a feeding movement at right angles to the axes of the cutter-spindles and along one extension of the L-shaped base or bed. The particular work-table shown in the illustration is of heptagonal form, there being seven equal sides or faces. This machine is used in the plant of the Davis Mfg. Co. for milling the parallel sides of engine bearings. Another work-table which has been designed for this type of machine is circular in form and has a T-slot extending around the periphery. The fixtures intended for use with the circular table have tongues that fit into the T-slot. The bases, which are bolted against the work-table, are machined to the proper radius on an ordinary boring mill, and when applied to the milling machine table, can be moved around the periphery of the table so that there is a minimum amount of space between them. The design of these jigs can, of course, be modified to suit the different classes of work for which the machine is adapted. Experience has demonstrated, however, that it is economical to have the work-table fitted up for specific operations, one table replacing the other when a change of operations is made. This change of work-tables can be effected much more quickly than by using the same table and replacing one set of jigs or fixtures with another. The circular table is 4 feet, 10 inches in diameter, which is also the width between the faces of the work-table illustrated.

The tubular sleeve or spindle for the work-table is mounted in an exceptionally large bearing and the cutter-spindle housings are rigidly bolted to the bed so that vibration and chatter are eliminated. The work-table is driven through worm-gearing which gives a smooth, powerful drive. The necessary feed changes and the control of the feeding movement are obtained through suitable gearing and friction clutches. This feeding mechanism is enclosed by the casing seen at the left-hand side of the illustration. The slide or carriage for the work-table is adjusted along the bedplate to locate the work in the right position relative to the cutters.

The cutter-spindles have the ordinary conical, bronze, adjustable bearings. The lower spindles are located within sleeves to provide endwise adjustment for taking the finishing cut, and to compensate for the wear of the cutter. The housings which carry the milling cutter spindles are held in position by four bolts located at an angle of 45 degrees. The inner ends of these bolts engage suitable grooves, and, owing to their angular position, each housing is drawn firmly down against the bed and also against the casting containing the driving gears. When this machine is in operation, the continuous feeding movement is so regulated that one man is kept busy removing the finished parts and inserting rough castings.

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## KANE & ROACH STRAIGHTENING AND SHEARING MACHINES

Kane & Roach, Niagara and Shonnard Sts., Syracuse, N. Y., are the manufacturers of the automatic straightener and shear, and the hot roll straightener described in the following. The straightener and shear is intended for rolling mills, and especially for tool-steel mills. It is designed to straighten flat strips from coils of stock and to cut off automatically any length desired. The dumping table which receives the cut-off stock operates automatically. This No. 1 machine (see Figs. 1 and 2) is designed to handle material varying in width from 3 to 10 inches and in thickness from 1/32 to 1/8 inch. The adjustment on the table can be set to cut practically any required length, and during the shearing operation the rolls stop feeding automatically. The instant the piece of stock is sheared off the table automatically dumps the strip of material and returns to its normal position. After the table returns, the shears stop, open a little, and the rolls start to straighten and feed out a new length of stock. This cycle of operations is repeated as long as there is any material to run through the rolls. The stock passes through the machine at the rate of from 100 to 125 feet per minute, and sometimes the feed is as high as 150 feet per minute. Machines of this type are made in several different sizes and may be used for cutting

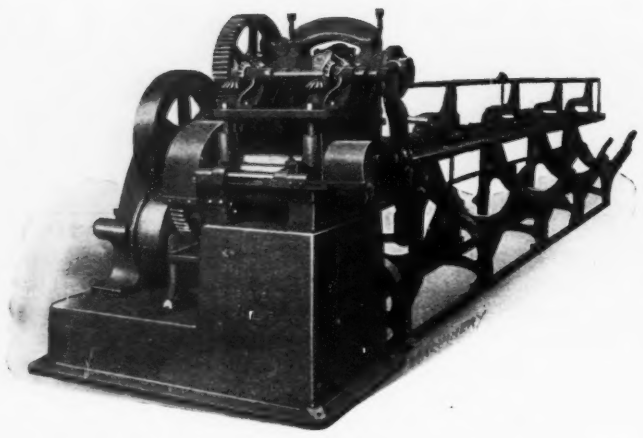


Fig. 1. Kane & Roach Automatic Straightening and Shearing Machine

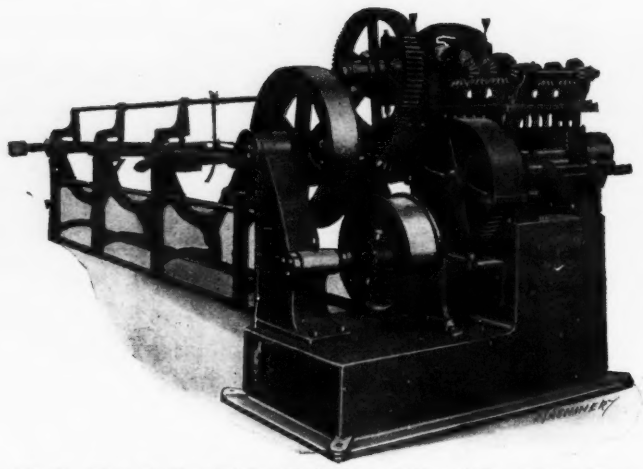


Fig. 2. View showing Driving Mechanism of Kane & Roach Straightener and Shear

and straightening brass, copper, steel, or any kind of material desired.

The straightening machine shown in Fig. 3 has also been brought out by this firm. This machine is intended primarily for straightening round stock while hot and just as it comes from the rolls. Material can also be straightened while cold, although the larger bars should preferably be straightened while hot. The hot bars, after passing through the machine, are given a regular blue finish and the surface is smoothed or polished almost as though the bar had been cold-rolled. When bars are straightened while cold they are also given a good finish and are made true or straight, but the surface does not have as good a finish as that of stock which is straightened while hot. The straightening of a bar is accomplished in one passage through the machine, and the material moves at the rate of 20 to 25 feet per minute.

These machines are made in four or five different sizes. The No. 17 hot roll straightener may be used for stock varying from ½ up to 1½ inch in diameter. The No. 18 size, which is shown in Fig. 3, straightens stock varying from ½ inch to 2½ inches in diameter. The No. 19 size will take stock from 1 inch up to 3¼ inches in diameter; and the capacity of the No. 20 size is for diameters varying from 2 to 5 inches. These machines may be driven either by a belt or motor, the belt drive being shown in the illustration. A different base is used for the motor drive and the motor is geared directly to the machine. The tables at each end of the machine for supporting the stock are about 15 feet long and may be adjusted vertically to suit the diameter of material being straightened. There are also guide boxes and guides between the rolls of different widths and heights to suit the diameter of stock.

The particular machine illustrated in Fig. 3 has what is known as an independent adjustment; that is, each side or each corner can be adjusted independently and can be locked tightly after the adjustment is made. These machines may also have a universal adjustment which is so arranged that all four adjusting screws may be operated by turning one handle from either side of the machine. With this type the rolls are adjusted either toward or away from a common center and are always kept in accurate alignment. The No. 18 machine weighs about 7½ or 8 tons and occupies a lengthwise space of about 36 feet. These machines are designed to enable rolling mills to produce round shafting and round steel bars which are straighter and have a better finish than the round stock that is ordinarily obtained.

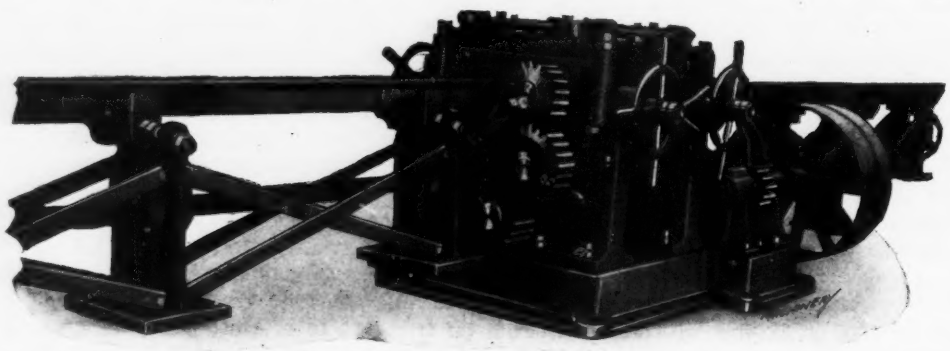


Fig. 3. Kane & Roach No. 18 Hot Roll Straightener

## OLIVER MACHINERY CO.'S LATHES

The engine lathes illustrated in Figs. 1 and 2 are recent products of the Oliver Machinery Co., Coldbrook and Clancy Sts., Grand Rapids, Mich. The 26-inch heavy-duty lathe illustrated in Fig. 1 has an all-geared headstock and it may be motor-driven as shown in the illustration or arranged for a single-pulley belt drive. Twelve spindle speeds varying from 8 to 300 revolutions per minute are available. The speed control levers are conveniently located at the front of the headstock and the speed changing mechanism operates on the selective principle. The front spindle bearing is 6½ by 10 inches, and the rear bearing 4½ by 7 inches. The hole through the spindle is large enough to receive a 3-inch bar of stock. The tailstock spindle is 4 inches in diameter and is rigidly held by clamps acting on two sides. The tailstock is adjusted along the bed by means of a crank connected through gearing with the feed rack.

The carriage has a length of 40 inches on the shears and there are two methods of adjusting it by hand. One is by means of the regular handwheel which is used when the carriage is in position for taking a cut, and the other by using a rapid-motion crank which is applied to the extended end of the intermediate gear shaft between the handwheel and rack pinion shaft. The apron is of the double-plate box type with bearings at both ends of each shaft. The apron has a removable front plate which gives access to the internal mechanism without removing the entire apron from the lathe. Both the longitudinal and cross feeds are friction-driven and may be thrown into action by means of the same lever. The arrangement is such, however, that both feeds cannot be engaged at the same time, and means are also provided for locking the feed mechanism against operation when the lead-screw is in use.

The changes for feeding and thread cutting are obtained from the quick-change gear-box below the headstock. Thirty-three feed changes are available, ranging from 0.013 to 0.333 inch per revolution of the spindle. Thirty-three threads varying from 1 to 16 per inch may also be cut by simply changing the lever positions as indicated by the table on the gear-box. Either direct- or alternating-current motors of the constant-speed type may be applied to the headstock, and from 7½- to 15-horsepower motors are recommended, the size depending somewhat upon the nature of the work. The taper attachment is secured in place by a wide planed slide on the back of the bed, which has a T-slot in it to which the

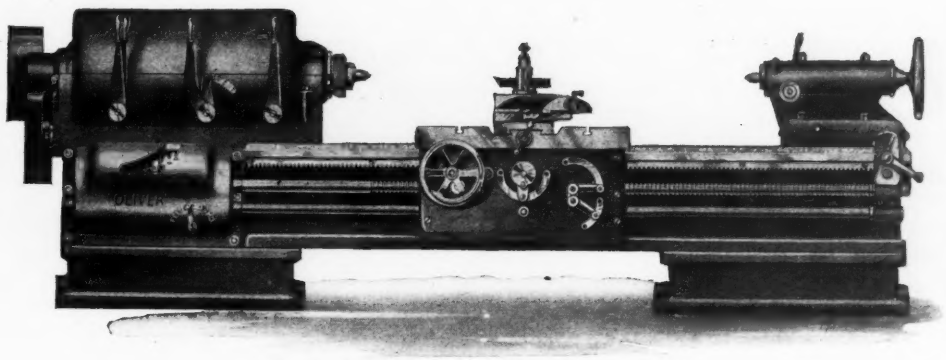


Fig. 1. Oliver Heavy-duty 26-inch Engine Lathe

holding bolts are locked. The swing over the bed is 28½ inches, and over the carriage, 17 inches. The maximum length between the centers is 72 inches. The general massiveness of the design throughout is apparent from the illustration.

The speed lathe illustrated in Fig. 2 swings a diameter of 12 inches over the bed and 9½ inches over the carriage. The machine will turn a length of 36 inches between the centers with a bed 60 inches long. This lathe is regularly equipped with a hand-feeding carriage and a compound swivel rest, but these may be omitted and a plain bed furnished if desired. The spindle has Parsons white bronze ring-oiling bearings that are adjustable for wear. The end thrust is taken at the ends of the cone pulley, which bear against bronze bushings. Adjustment is made by expanding the cone, the smallest step being threaded into the main part of the cone pulley. A motor drive may be applied to this lathe if desired. A special double adjustable motor bracket with foot-lever control is mounted below the headstock on the floor and attached to the machine leg. On this bracket a one-horsepower constant-speed motor is located. The motor shaft, which is extended and supported at the outer end, carries a four-step cone pulley, from which an endless leather belt runs through the enlarged headstock up to the headstock cone pulley.

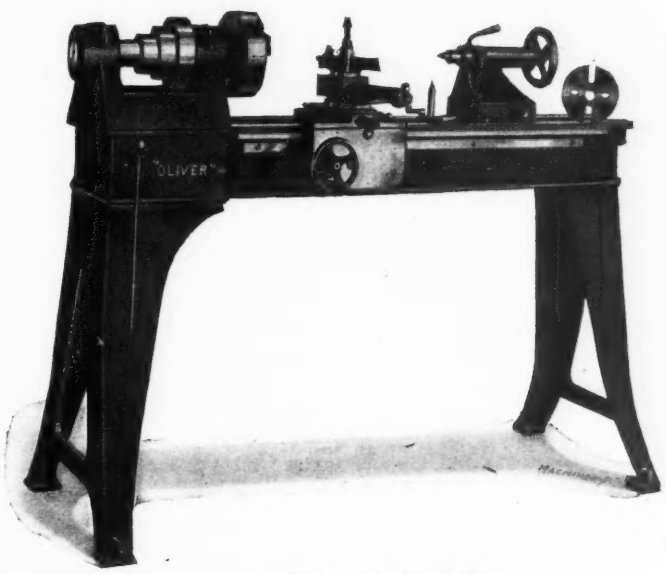


Fig. 2. Oliver 12-inch Speed Lathe

## AKIMOFF DYNAMIC BALANCING MACHINE

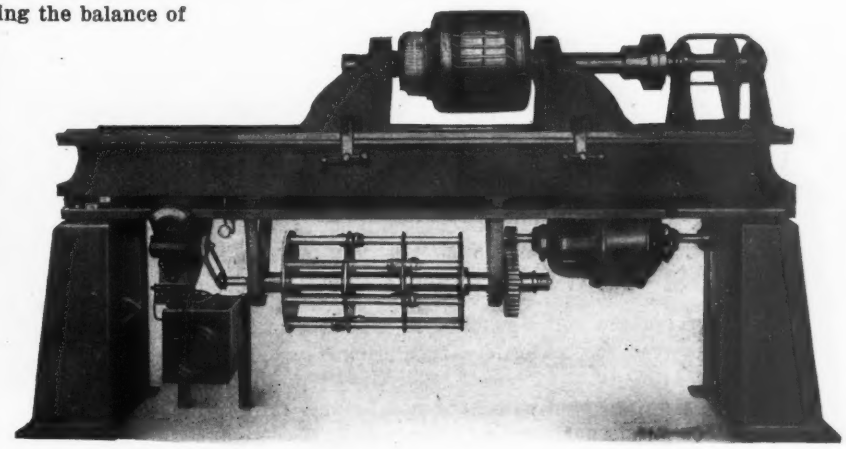
Manufacturers of high-speed machinery realize the importance of a dynamic or running balance for parts which revolve rapidly, in order to prevent trouble from vibration, excessive power consumption and abnormal wear of the bearings. The machine illustrated herewith is used for testing the balance of such parts as motor armatures, turbine rotors, automobile crankshafts, etc. It is manufactured by the Dynamic Balancing Machine Co., Philadelphia, Pa. Balancing the rotating elements of electrical machinery and automobile crankshafts has, up to the present time, been the most successful application of this machine. The illustration shows the machine arranged for testing the balance of a motor armature. The power for revolving this armature and the balancing element of the machine is derived from a Westinghouse motor.

When a body is balanced statically and not dynamically, two masses on opposite sides of the axis of rotation, located axially at a distance from each other, form a couple which develops vibrations when revolving at high speed, as noted in defective commutators in electrical machinery, etc.

The Akimoff dynamic balancing machine furnishes means for determining the magnitude and plane of the couple, by the establishment of another couple, which, while maintaining the static balance, counteracts the couple which produces dynamic unbalance. The magnitude and plane of this couple indicates the correction to be applied to the body that is being tested to produce a perfect dynamic balance.

A rigid horizontal beam or bed is hinged at one end of the machine and supported by a spring at the other. The body to be tested, which should be in perfect static balance, is rotatively supported on the beam to vibrate in a vertical plane. The object of the spring is to amplify the vibrations. A so-called "squirrel cage" is located on the under side of the beam, and in operation is rotated in unison with the body being tested. This squirrel cage consists of two circular disks carrying an even number of rods, arranged slidably in the two disks and parallel to the axis of rotation of the cages. When the ends of the rods are in one plane, the cage is in both static and dynamic balance, but if two opposite rods are displaced, the dynamic balance is destroyed and the couple produced will itself cause vibration of the beam. One pair of rods in the squirrel cage would suffice if the relative position of the rods could be altered through the transmission device, but for convenience three or four pairs are employed, and even then it is sometimes necessary to change the angular position of the cage so that it will be possible to do the balancing by one pair of rods and not two.

In making the test of a body, the cage is adjusted so that the vibrations produced in the beam by the body are counteracted by those set up by the squirrel cage. An arrangement by which the rods of the cage may be adjusted axially while the cage is in rotation is provided, and the rods can thus be shifted the necessary amount until the desired balancing effect is produced.



Akimoff Dynamic Balancing Machine

## STANDARD FUSE BASE MILLING MACHINE

A highly specialized type of milling machine has been constructed by the Standard Mfg. Co., Bridgeport, Conn., for milling fuse bases. This machine is illustrated in Fig. 1, and an example of its work is shown in Fig. 2. The operation consists in milling two grooves across the fuse base at right angles to each other. After the base is inserted in the work-holding table, it is located in the correct position for milling the two grooves, and, after the milling operation, is ejected automatically. This machine is capable of cross-milling these fuse bases, as shown, at the rate of 900 an hour. It is driven by a belt operating on pulley *A*. This pulley transmits motion, through worm-gearing, to a cam-shaft, from which all parts of the machine receive their motion except the cutter-spindles. The two cutter-spindles are located at *B* and *C*. Both of these are carried by a vertical slide, which receives motion from a cam acting through lever *D*. By means of this lever the two cutters are moved downward for milling a groove of the required depth; and after the cutters have been located vertically they are traversed across the fuse base by a horizontal slide, the action of which is controlled by a cam on the rear shaft.

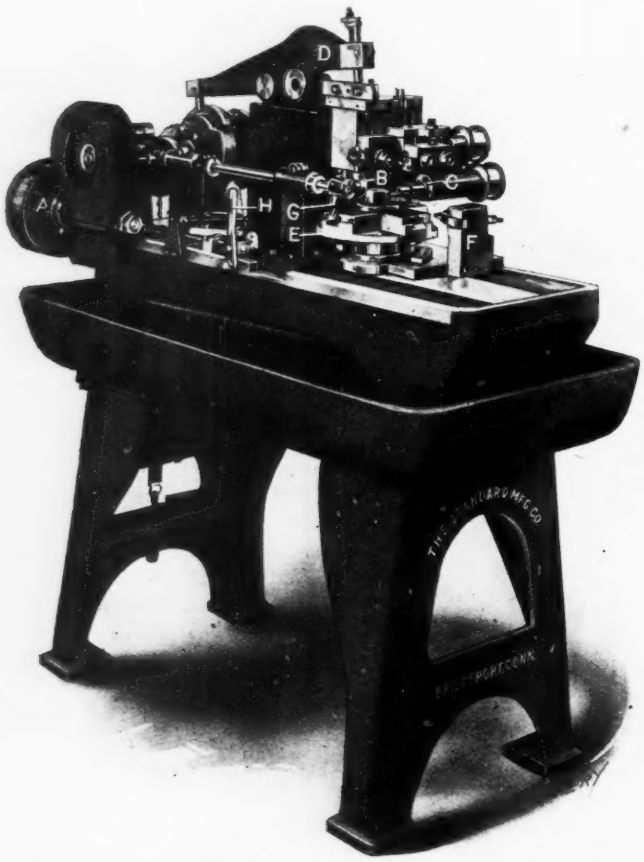



Fig. 1. Special Machine designed by Standard Mfg. Co. for milling Fuse Bases

As soon as a cut is completed, the cutters are raised by the cam-operated lever *D*, and during the return stroke of the horizontal slide the work-table *E* is indexed. This indexing movement is also derived from a cam on the rear cam-shaft, and after indexing, the work-table is securely locked in position. The bearing block for cutter-spindle *B* has both vertical and horizontal adjustment for changing the position of the cutter relative to the work. The bearing block for spindle *C* may also be adjusted vertically and horizontally independently of spindle *B*. Both the cutter-spindles are rotated from one belt, which operates over the small flanged pulleys shown in the illustration. The connection between lever *D* and the vertical slide carrying the cutter-spindles is provided with a micrometer adjustment for accurately regulating the depth of cut.

The work-table *E* is provided with hardened fixtures for receiving the work, and block *F* serves to locate each fuse base after the work-table indexes from the "loading position." When the work has been indexed past this locating block, it is held firmly in position by the action of a plunger beneath it, which is forced upward by a cam surface below the work-table. After the milling operations are completed, the work is released and ejected from the work-table by a finger *G*. The starting or stopping of the machine is controlled by the vertical lever *H*, which operates a clutch on the worm-wheel shaft. When a groove is milled by the cutter on spindle *C*, the fuse base is indexed 90 degrees, thus locating the first groove at right angles to the cutter on spindle *B*, which mills the second groove. Both cutters operate at the same time, so that a finished part is ejected from the machine each time the work-table indexes.

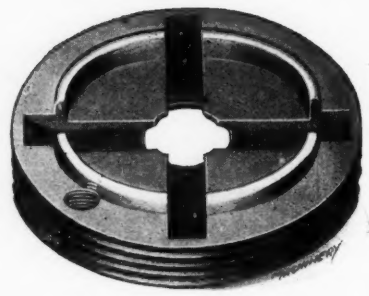


Fig. 2. Fuse Base which is milled in Machine shown in Fig. 1

## STEEL PRODUCTS ENGINEERING CO.'S GAGE GRINDER

The universal gage grinder now being manufactured by the Steel Products Engineering Co., Springfield, Ohio, is adapted for grinding all classes of snap or master gages and it may also be used for various classes of special work. Gages having a maximum depth of 4½ inches and a maximum length of 21½ inches may be ground. Fig. 1 illustrates the general construction of the machine, and Fig. 2 shows more clearly the relation between the grinding wheel and the work-table.

The wheel-spindle is of the floating type designed to eliminate the jerk of the driving belt. The cross-feed is operated by the hand-lever seen at the left-hand end of the table in Fig. 1, which transmits motion through a rack and pinion. This lever provides a quick movement for removing an excessive amount of stock. In conjunction with this lever feed a fine feeding movement may be obtained by a handwheel which connects with a screw of fine pitch. This feeding movement is used when extreme accuracy is required or when it is desired to obtain a smooth finish.

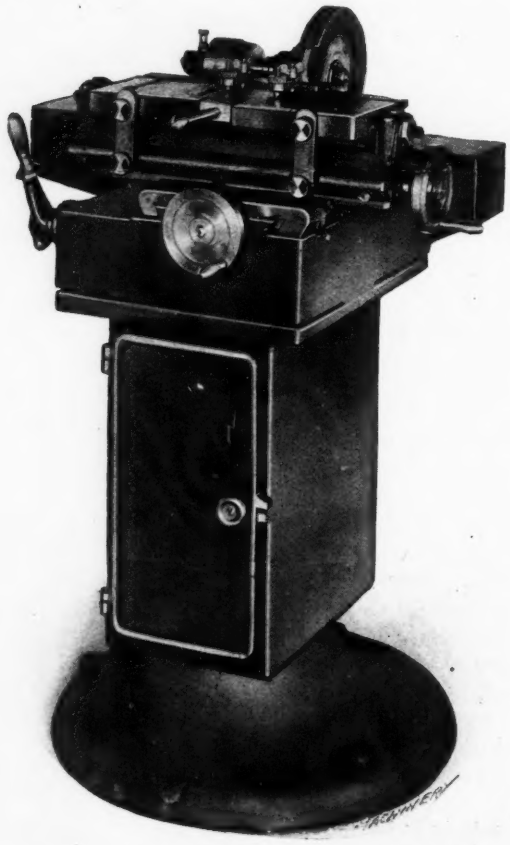


Fig. 1. No. 1 Universal Gage Grinder built by Steel Products Engineering Co.

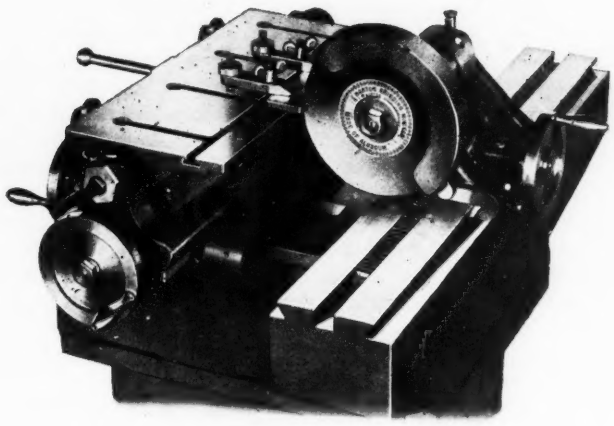
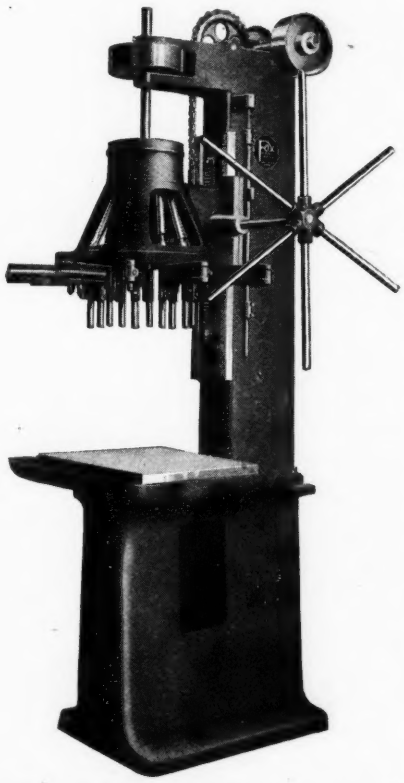


Fig. 2. Work-table and Wheel-slide of Gage Grinder

The ways on which the carriage slides, are covered with telescoping dust guards to protect the bearing surfaces. The table has a flat working surface on which the gages or other parts are fastened by means of strap clamps as illustrated in Fig. 2. A gage is used for locating duplicate parts. The table may be tilted upward or downward through an included angle of 10 degrees. This adjustment permits locating the center of gages of different thicknesses in line with the center of the wheel. The traversing movement is regulated by a feed-screw and handwheel graduated to read to 0.0005 inch. The table may be traversed 4¼ inches by means of this handwheel, and an additional 17½ inches in the same direction by the spindle-head adjustment. The stand or base of the machine has compartments for storing tools, grinding wheels, etc.

## FOX MULTIPLE-SPINDLE DRILLING MACHINE

A small multiple-spindle drilling machine of the sensitive type is the latest addition to the line of drilling machines manufactured by the Fox Machine Co., 1401 W. Ganson St., Jackson, Mich. This machine, as it is regularly built, is shown in the accompanying illustration; it can, however, be converted into a machine of the bench type, if so desired, by mounting it on a suitable baseplate. The table is cast separate from the base so that tables of different size or special fixtures can be mounted on the base. The table has a wide oil flange in which are cast T-slots for receiving clamping bolts so that jig stops may be fastened to the table.



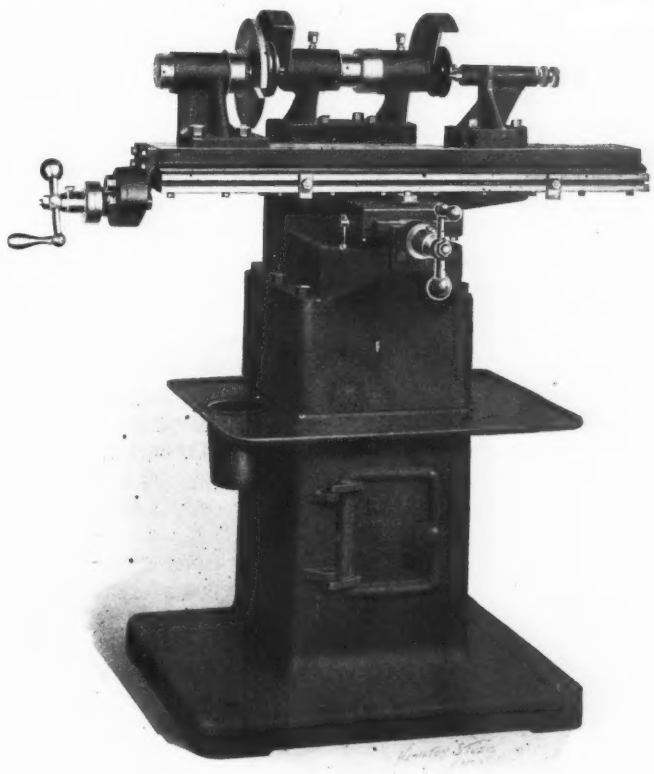
Fox D-01 Sensitive Multiple-spindle Drilling Machine

These machines are equipped with either 9-inch or 12-inch round heads. These heads can be provided with from two to ten spindles one inch diameter or from two to sixteen ¾-inch spindles. A six-arm pilot wheel keyed to the rack pinion shaft gives sufficient leverage for feeding the drills easily. All pinions are of open-hearth machinery steel (0.30 per cent carbon) and have double bearings turned integral with them. The gears run constantly in an oil bath.

This machine has a new type of adjusting arm, so that the adjustments may be made rapidly and the bearing held securely to the arm. The universal joints used in the machine are composed of three wearing parts only. The two forks and the center are milled from the solid and are hardened. No pins, screws or rivets are used in the construction of these joints. The drill spindles are of crucible steel, and provision is made for receiving the thrust upon ball bearings. The manufacturer is prepared to furnish cluster plates for these machines. These plates are used for a complicated lay-out when arms of the regular type cannot be employed.

## RAM GRINDING MACHINE

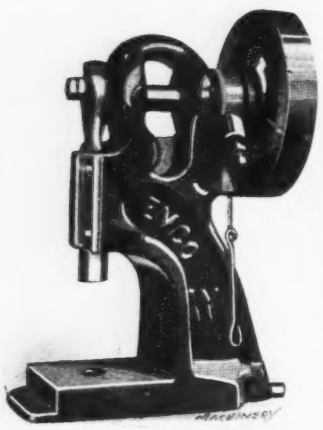
The grinding machine illustrated herewith is manufactured by the Richmond Adding & Listing Machine Co., Richmond, Ind. While this machine is known as a plain grinder, it is adapted for internal as well as external grinding operations, and is equipped with an adjustable tailstock which permits taper work to be ground. The machine may be used for tapers up to 10 or 15 degrees, the angle depending upon the length of the work. The longitudinal and cross feeding movements are hand-operated and the feed-screw dials are graduated for adjustments of 0.001 inch. The machine has a swing of 10 inches and will take 28 inches between centers. Grinding wheels 8 inches in diameter and 1 inch wide can be used. The wheel-spindle is hardened and ground and is mounted in adjustable manganese-bronze bearings. The headstock spindle is threaded to receive a chuck and faceplate and is provided with adjustable manganese-bronze bearings. The tailstock spindle is operated by a spring lever to permit inserting and removing work rapidly. It also has an adjusting screw and lock-nut for holding the center rigidly when grinding heavy parts. The attachments for this machine include a headstock for cylindrical grinding, a headstock for internal grinding, 3½-inch and 8-inch faceplates, a tooth rest for use when grinding small cutters, reamers, etc., and a clamp post for wheel dressing.



Ram Grinding Machine built by Richmond Adding & Listing Machine Co.

## ENTERPRISE PUNCH PRESS

A small power-driven punch press of the bench type has been brought out by the Enterprise Machinery Co., 34 S. Clinton St., Chicago, Ill. The aim of the manufacturer has been to produce a power press which will not cost more than

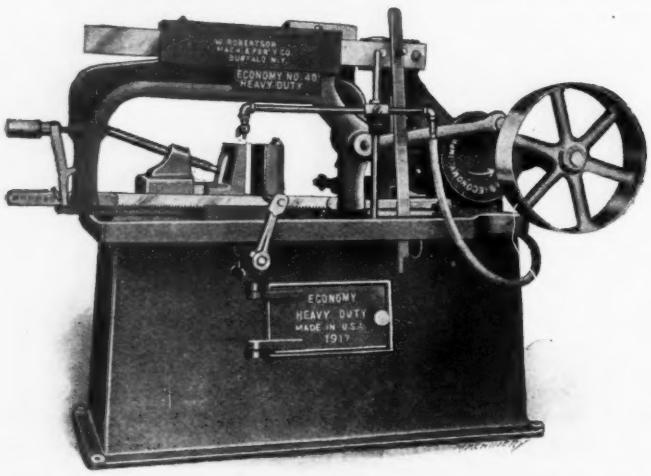


Power-driven Punch Press of Bench Type

foot-operated presses and will do the same work by power. This machine is intended for the use of jewelers or manufacturers of electrical parts and work made of light metal, fiber or wire. The press may be bolted in an inclined position for discharging by gravity and can be fitted with an automatic feed for high-speed production. The stroke is ¾ inch and there is ½-inch adjustment. The depth of the throat is 3⅜ inches, and the die space, 4 inches. There are two striking pins, a brake and a standard clutch. This punch press is 20 inches high and weighs 110 pounds.

## ROBERTSON HEAVY-DUTY POWER SAW

The W. Robertson Machine & Foundry Co., 56-58 Rano St., Buffalo, N. Y., is now manufacturing a heavy-duty power saw having a capacity of 8 by 8 inches. This machine uses blades varying from 10 to 17 inches in length, and like the other sizes built by this company, cuts on the draw stroke and lifts on the return stroke. The lifting of the frame to prevent the teeth from dragging over the work is effected by an oil compression lift, consisting of a two-cylinder plunger pump submerged in oil contained in a tank beneath the bed. One plunger is connected to and timed with the crankshaft, and the other is connected to the frame. In one cylinder there is a steel ball which acts as a valve. On the cutting stroke oil is drawn into the cylinder, and at the end of this stroke the ball seats, and the plunger starts downward, which forces the opposite plunger connected with the frame upward, thus relieving the saw on the return stroke. At the end of this idle or return stroke, the plunger passes a small port in the cylin-



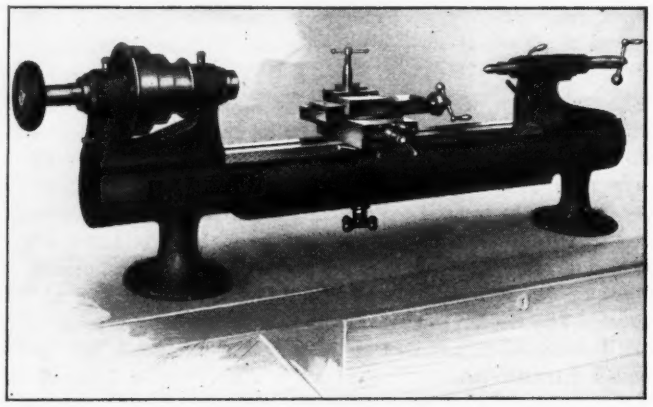

No. 40 Power Saw manufactured by W. Robertson Machine & Foundry Co.

der wall, which allows the oil to escape into the tank, so that the saw blade comes down into contact with the work for the cutting stroke. By means of a simple adjustment the lift may be varied from 0 to ⅜ inch.

The box base forms a large receptacle for holding the cooling liquid, which is delivered to the saw blade by a piston pump, operated by an eccentric. The volume of liquid is controlled by a cock at the end of the supply line, and any surplus drawn into the pump is returned to the tank by the automatic action of a valve in the pump. The pump valves are steel balls operated by suction and gravity. The machine vise is a quick-acting type and swivels to 45 degrees for cutting at an angle. The weight on the saw blade when cutting may be varied from 0 to 65 pounds. The machine can be furnished with legs instead of the box base if desired, and with either a belt or motor drive. It is also made in either single-speed or two-speed types.

## COTTON BENCH LATHE

H. W. Cotton, Inc., 233 Broadway, New York City, is the manufacturer of the bench lathe illustrated herewith. This lathe has a swing of 7 inches and a 36-inch bed. The collet capacity is for diameters up to ⅝ inch. The spindle has the usual 3- and 45-degree angles, as this form of spindle has met with general approval. The spindle bearings are oiled from a channel around the outside of the bearings in the headstock. The oil is conveyed from the oil-well through a piece of felt placed in a slot in the bottom of the bearings and extending upward to the spindle. This arrangement allows any foreign matter which may enter the oil chambers to settle to the bottom, and the felt makes it impossible for the grit to reach



Cotton 7-inch Bench Lathe

the spindle bearings; in addition, this provides a continuous oiling system. The bench lathe is provided with either a two-speed or three-speed countershaft as desired, and with a 12-inch grooved pulley for grinding with the usual grinding attachments.

## NOBLE & WESTBROOK FILING MACHINE

The filing machine shown in the accompanying illustration was developed by the Noble & Westbrook Mfg. Co., Hartford, Conn. The machine is equipped with a three-step cone pulley for the driving belt, as experience has demonstrated that changes of speed are an advantage for filing varying classes of work. The foot-treadle seen at the base of the machine is connected to a clutch in the main drive and provides a convenient method of control. When the foot-treadle is pushed down by the operator, the machine is started, and when it is released the reciprocating motion of the file is immediately discontinued. The lower end of the file is steadied by a hardened roller bearing, which may be adjusted by knurled adjusting screws at the sides of the table. As this bearing takes the lateral thrust against the file, the latter may be subjected to considerable pressure when rough-filing without bending and breaking the file.

Noble & Westbrook Filing Machine

All bearings are made of phosphor-bronze and the working parts are above the file, so that the fine chips or filings cannot enter the bearing surfaces and cause excessive wear. When the machine is used for angular work, such

as filing the clearance in blanking dies, etc., the table remains fixed and the head is adjusted. The circular flange at the base of this head is graduated so that the file can be set at whatever angle is required without the use of a bevel protractor. The table is solidly supported by the column of the machine. The stroke of the file may be adjusted from 1½ inch to 2½ inches. The machine is provided with an adjustable chuck for holding standard straight files without any additional work, such as babbitting, etc.

## THERMALENE FOR WELDING AND CUTTING METALS

The Thermalene Co., Chicago Heights, Ill., is manufacturing the welding and cutting outfit shown in Fig. 1. The thermalene used in connection with this apparatus differs in composition and method of production from the gases heretofore used in welding, cutting and brazing operations. Thermalene

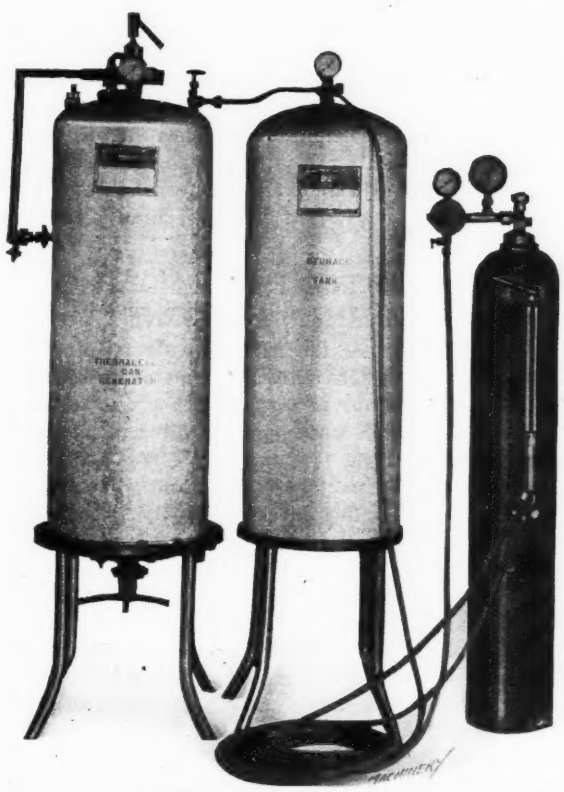


Fig. 1. Thermalene Welding and Cutting Apparatus

is a combination produced by the decomposition of calcium carbide and hydro-carbon oils, the heat generated by the carbide being used to vaporize the oils. The thermalene gas generator is shown at the left in Fig. 1 and the storage tank in the center. This acetylene oil gas may be used not only for welding, cutting, brazing and soldering metals, but also for lighting heating laboratory work and for a variety of miscellaneous purposes. Ten pounds of carbide and one and one-half pint of crude oil mixed with sawdust generates about 60 cubic feet of acetylene oil gas at a cost of 25 cents. This gas was formerly made in two separate plants, but with the apparatus here illustrated the gas may be generated at one time under any pressure desired and without danger from explosion or overheating of the carbide.

Fig. 2 shows an automatic seam-welding machine for welding tubes; this was built especially for making tubing from scrap rails, which contains a great deal of carbon. It is claimed that this work could not be done with acetylene and oxygen, but that thermalene, being a heavier and richer gas, mixes better with oxygen and produces satisfactory welds. This seam-welding machine operates at the rate of 30 to 34 inches per minute, and as it is a duplex type, from 60 to 68 inches per minute of 1¼-inch tubing of No. 14 inch gage may be welded. Thermalene

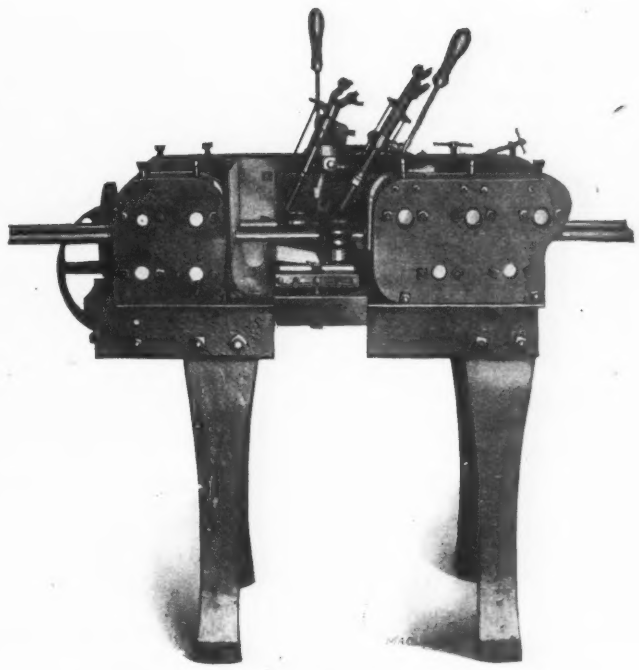


Fig. 2. Automatic Seam-welding Machine for Tubes, which operates with Thermalene Gas

gas is said to make a weld that is not brittle, and cast iron welded with it can always be machined.

## BICKFORD TWIST DRILL FLUTING MACHINE

The twist drill fluting machine illustrated herewith is made by the Bickford Machine Co., Greenfield, Mass. This machine has been redesigned and embodies a number of important features not found in the type formerly manufactured. The drill blank to be fluted is held in a chuck, and the drill advances through a bushing which supports it while the cutter is milling the flute. After the drill blank is inserted in the chuck, the operation of the machine is entirely automatic until the two flutes are milled, when the feed is discontinued. The carriage, which holds the drill chuck, is moved forward and back by a crank-wheel, the crankpin of which engages a slot in an L-shaped arm as shown in Fig. 2. With this arrangement the carriage is given a practically constant rate of motion while the drill flute is being milled. This uniform movement is obtained by placing the fulcrum of the slotted lever out of line with the slot in which the crank-block travels.

The angle between the cutter-spindle and the line of carriage travel or the axis of the drill blank may be varied. A train of gearing between the cutter-spindle and feed shaft enables different feed ratios between the shafts to be obtained. The drill blank has a relatively high speed while the cutter is not working and a low speed while the flutes or grooves are being milled. This change is effected by a gear-box containing a set of differential gearing and clutches with means for shifting

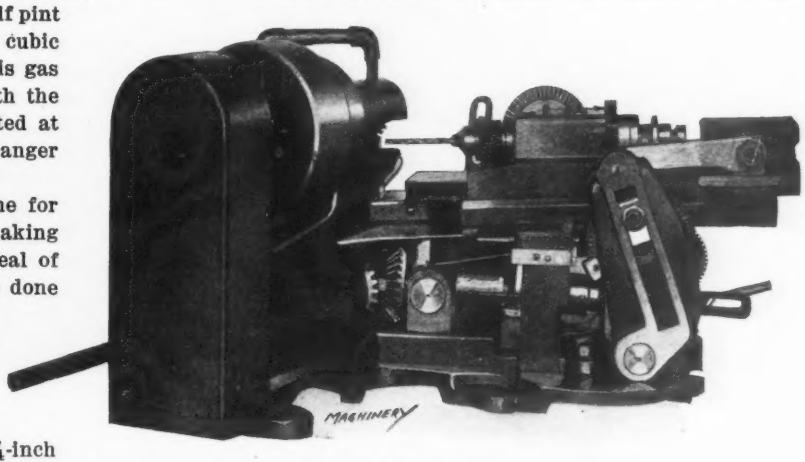


Fig. 1. Bickford Twist Drill Fluting Machine

from high to low speed and *vice versa*. This change of feed is controlled by a set of adjustable trip dogs mounted on the periphery of the crank-wheel. A rotating motion is given to the drill blank as the carriage slide advances, through a combination of spur and bevel gearing. This machine is so arranged that the lead of the spiral and the increase in the lead or twist may be varied. The combination of a friction plate, clutches and trip dogs serves to stop the rotation of the drill blank temporarily during its backward travel while the rotating mechanism is still operating, so that the drill blank is indexed for milling the second flute or groove. Provision is made for adjusting the movement of the carriage slide both for length and position.

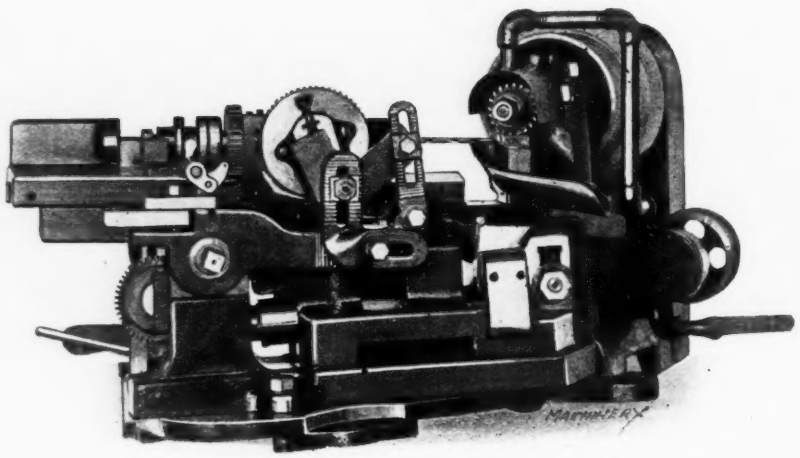


Fig. 2. Opposite Side of Bickford Fluting Machine

## PUTNAM HEAVY-DUTY CAR-WHEEL GRINDER

A heavy-duty car-wheel grinder has been developed by the Putnam Machine Co., Fitchburg, Mass., that has a capacity in wheel diameters from 28 to 42 inches over the tread. The actual swing of the machine is 44 inches and axles up to 8 feet in length can be placed between the centers. The machine is entirely self-contained, as shown in the accompanying illustration, and the driven parts are directly connected to motors, thus eliminating belts. The faceplates have an independent motor drive, power being transmitted through a large shaft and gearing giving a suitable speed reduction. The faceplates are equipped with patented non-slip driving dogs which require no adjustment other than to release them by hand when the wheels are in position. The design of the dogs is such that the engagement is entirely automatic. The main spindles have adjustable sleeves so that variations in different axles are automatically compensated for and the "dogging distance" from the faceplate to the face of the wheel remains constant.

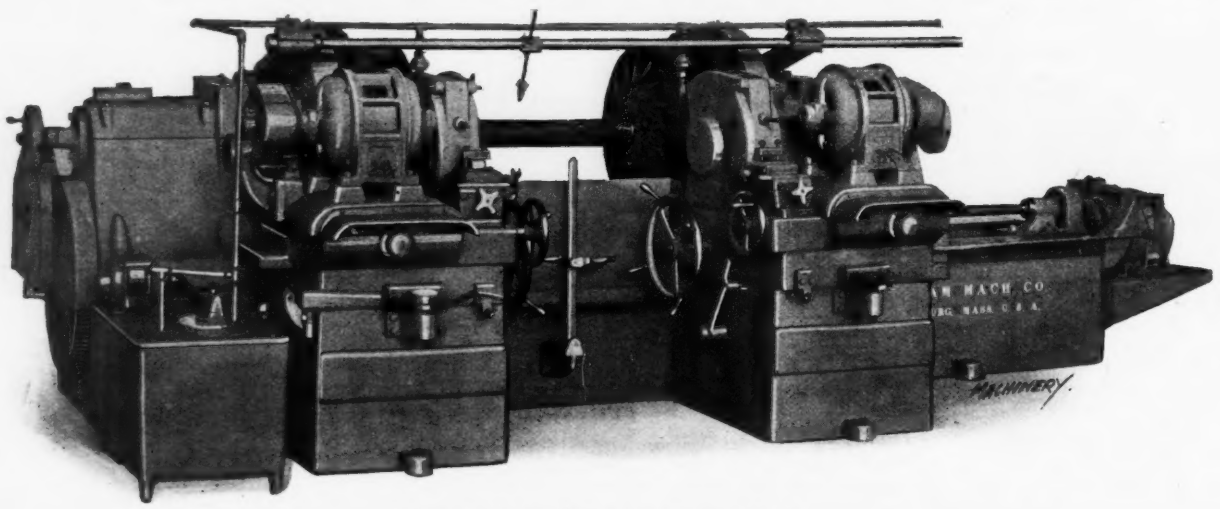
The grinding wheels are mounted on large high-carbon steel spindles with tapered bronze bearings having oil reservoirs. Ball bearings are used to take the thrust of the spindles. The bases for the grinding wheel slides are cast integral with the main bed of the machine, which gives a rigid support and insures a permanent alignment for the grinding-wheel spindles. The grinding wheels may be adjusted for the different standard wheel contours by a simple mechanism which may be operated while the machine is running. The grinding wheels are driven by means of individual motors which are directly connected to them through gearing.

Provision is made for furnishing a cooling compound to the working faces of the grinding wheels by means of a motor-driven pump and the necessary piping. Special pans and channels are provided throughout to confine the spray and prevent, as far as possible, the splashing of the cooling compound about the machine and floor. All gears and other dangerous parts are carefully guarded. The headstock of this machine is solidly bolted to the bed and the tailstock may be adjusted longitudinally by power derived from a separate motor. The tailstock is equipped with a patented automatic clamping device so that as it reaches the operating position it is clamped rigidly to the bed. The machine has a self-contained calipering attachment which forms part of the regular equipment. The net weight of the machine is 5000 pounds.

## FEED MECHANISM FOR ANDERSON DIE FORMING MACHINE

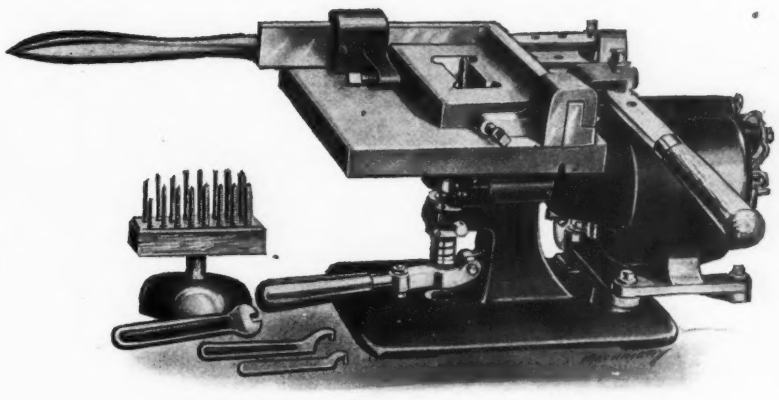
The first conception of the Anderson die forming machine and "super-helical" cutters was the result of an effort to find some more rapid way of performing those operations in the making of a die which were done by filing, either in a machine or by hand. Used by hand, a file requires great skill in order to secure satisfactory results, and when used in the machine it must be applied on one side only in order to make the draft or clearance uniform. With the use of the Anderson "super-helical" cutters in the die forming machine, the clearance is secured by tapering the cutter the proper amount; then by having the axis of the cutter at right angles with the table or platen a clearance will be produced in the die that is equal to the degree of taper on one side of the cutter, no matter from what direction the die is applied to the cutter.

In its original form, no mechanical means were provided on the die forming machine for controlling the die during the operation. This shortcoming has been realized by experience, and has led to the development of a universal pivoted feeding mechanism, illustrated in the accompanying illustration, which requires little or no explanation to make it clear to the average mechanic. The die rests upon the table or platen, and is secured to an arm or fixture by a pair of adjustable dogs or clamps. This fixture also rests on the platen and is pivoted to a lever at the rear of the platen. The lever



Car-wheel Grinder built by Putnam Machine Co.

has a series of holes placed about an inch apart, into which a plug can be inserted after passing through one side of a forked projection. This serves to locate the fixture and die so as to reach the opening in the die. The lever, in turn, is pivoted to an arm extending from and secured to the table. The pivot point for the lever is adjustable so that fixture and arm can be moved forward and backward in order to reach any part of the die.



Anderson Die Forming Machine with Universal Pivoted Feeding Mechanism

If the operator should desire to feed the die by hand in fitting a templet, the fixture can be removed in five seconds and placed on the bench, leaving the platen free. When the fixture and lever have been adjusted to the best location with respect to the opening in the die, the machine or cutter is started, and the die can be fed or guided so as to finish practically any outline without the operator's touching the die with his hands. From the foregoing it will be readily seen that this principle has made it possible to provide a means for guiding the die that relieves the operator of the necessity of holding the die with his hand, and still is so sensitive that the most intricate outline can be followed without difficulty. This fixture is now furnished as regular equipment on the No. 1 die forming machine made by the Anderson Die Machine Co., 590 Water St., Bridgeport, Conn.

## THOMSON THREAD MILLING MACHINE

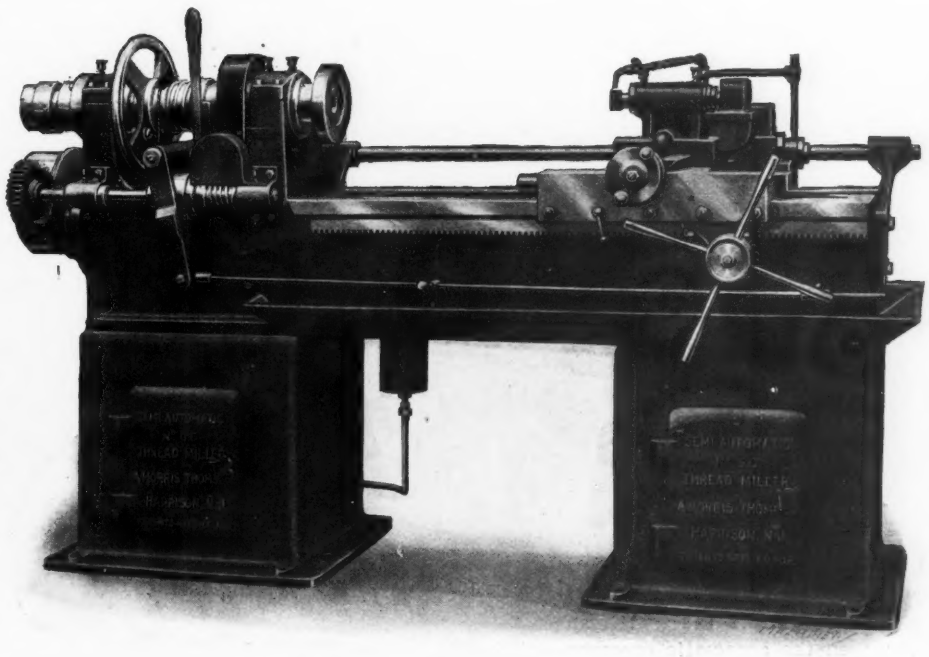
The machine which forms the subject of the following description is known as a Type 6-C thread miller and is built by the T. C. M. Mfg. Co., Hunterdon and First Sts., Harrison, N. J. It is suitable for milling internal or external threads on pieces up to 6 inches in diameter by 34 inches in length, and finds application in threading the smaller sizes of shells, water jackets, trunnion blocks, and other parts of machine guns. The machine is also employed for threading automobile parts, such as hubs, differential cases, universal joint members, and other parts having a comparatively short thread of a pitch not greater than ten threads per inch. This machine only performs the threading operation and no provision has been made for facing the work.

The spindle is made of steel and is 3 inches in diameter with a hole 1½ inch in diameter running through it. Heavy split bronze bearings support the spindle, and a threaded sleeve is fastened to the rear end to give the required lead to the thread that is being cut. This sleeve is engaged by a bronze nut which is split to provide means of compensating for wear, and these parts are easily exchanged for others suitable for cutting threads of different pitch. The front end of the spindle carries a faceplate to which a chuck or special fixture can be bolted, according to the requirements of the work that is being operated upon.

The cutter-spindle is made of tool steel hardened and ground to size. It runs in conical bronze bearings which are easily adjusted to compensate for wear. A cross-slide on the main carriage supports the cutter-head, and is operated by a feed-screw with a large graduated collar to give accurate adjustment for depth of cut. A substantial stop provided with micrometer adjustment enables accurate dimensions to be held on repetition work. The main carriage is traversed along the ways by a rack and pinion and its location is determined by the aid of an adjustable stop which is so designed that it may be rapidly operated.

The cutter-head is firmly locked to the carriage, and the carriage to the bed of the machine during the time that the thread is being milled, the only moving parts being the work-spindle, the work and the revolving cutter. This arrangement, together with the lead-nut, which is practically one piece with the work, insures obtaining a maximum degree of accuracy and the greatest possible speed and feed without trouble from chatter. The cutter is driven by skew gearing from a longitudinal shaft placed at the rear of the machine, and a single pulley transmits the power to both cutter- and work-spindles. A clutch operated by a hand-rod along the front of the machine gives the operator complete control over the work. This clutch is automatically thrown out when the thread milling operation has been completed, without requiring attention from the operator.

The regular equipment furnished with the machine includes the following: an oil pump and piping, a six-inch scroll chuck, a set of change-speed gears, a steadyrest, one multi-cutter of the desired pitch, and a set of wrenches for making all adjustments. The machine is driven by a countershaft having pulleys 12 inches in diameter by 4 inches face width, which run at 300 revolutions per minute. The machine pulley speed is 200 revolutions per minute, and five horsepower is required for driving the machine. The principal dimensions of the machine are as follows: capacity, for handling work up to 6 inches in diameter by 34 inches in length; over-all length of machine, 6 feet, 6 inches; over-all width, 3 feet; and weight of machine, complete, 2800 pounds.



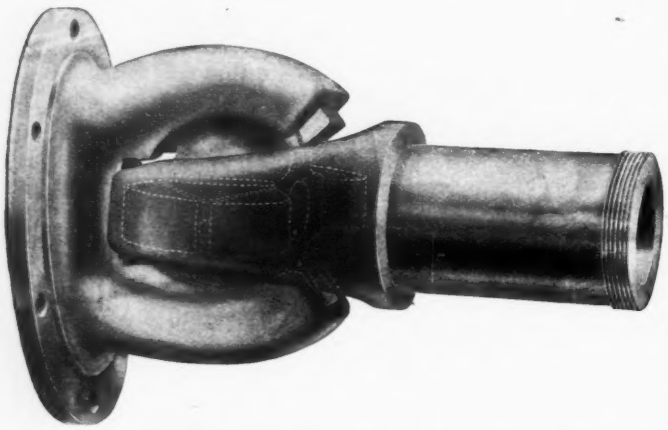
Type 6-C Thread Milling Machine built by the T. C. M. Mfg. Co.

## PLANK UNIVERSAL JOINT

For use in pleasure cars and commercial trucks, the Plank Flexible Shaft Machine Co., Grand Rapids, Mich., has recently placed on the market the three-piece universal joint illustrated and described. This joint is of simple construction, there being only three working parts, namely, a center block, a slip-end shaft yoke and one transmission flange yoke. These three parts make up the complete joint, and they are enclosed in a pressed-steel grease-tight housing which keeps all foreign matter out of the working parts of the joint and at the same time retains the lubricant.

A feature of the design is the liberal amount of bearing surface provided in the joint, which means that it will be correspondingly long lived. Lubrication is effected by centrifugal force which distributes the lubricant from the dead center toward the bearings. The bearings of the center block are housed in by a grooved yoke construction which retains the lubricant in the proper place at all times. This construction prevents the lubricant from being thrown away from the bearings by centrifugal force.

The center block is locked within the grooved yoke housing by means of a special construction which provides a bearing



Improved Three-piece Universal Joint made by Plank Flexible Shaft Machine Co.

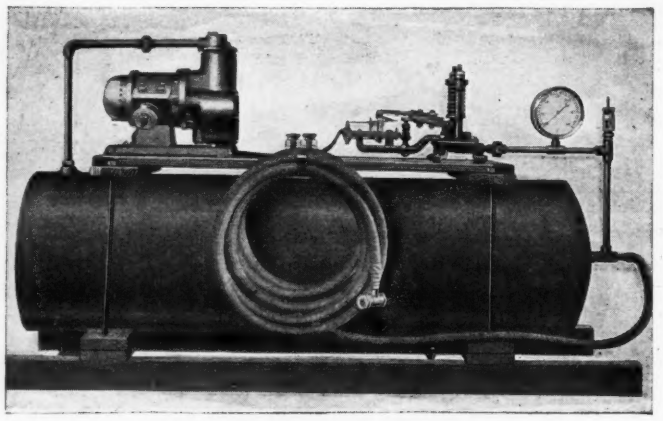
greater than 180 degrees and allows the center block, the outside diameter of which is equal to the inside diameter of the housing, to be circular. In this way a goodly amount of metal extends beyond the 180-degree center line and forms an interlock which will not allow the center block to be ejected. As a result, the center block is retained in its proper place without the use of pins, bushings, rivets or other parts.

All metal parts of this universal joint are made of drop-forgings, produced from a high grade of steel, and these are carefully machined. It is the intention to employ this same form of interlock construction in a smaller universal joint for use on milling machines, multiple-spindle drilling machines, etc. The design has been worked out in such a way that torsional strains are distributed over as large an area as possible, thus providing great strength for the center blocks.

## BLACK & DECKER "LECTROFLATER"

The Black & Decker Mfg. Co., Calvert and Lombard Sts., Baltimore, Md., is now manufacturing what is known as a No. 2 automatic "lectroflater" tank outfit. As suggested by its name, this is an electrically driven air compressor outfit developed especially for the purpose of inflating automobile tires. However, the outfit may be used to advantage as a portable air compressor for supplying such pneumatic tools as chipping hammers, riveters, etc., and in this class of service is capable of giving very satisfactory results.

To use the "lectroflater," it is simply necessary to connect the fuse block on the outfit with an electric light line, either alternating or direct current. It will immediately start working and keep on until the pressure in the tank reaches 150 pounds per square inch; then the automatic pressure switch shown on the right comes into action and stops the "lectroflater." When enough air has been used to cause the pressure



Black & Decker "Lectroflater" Tank Outfit for inflating Automobile Tires and operating Pneumatic Tools

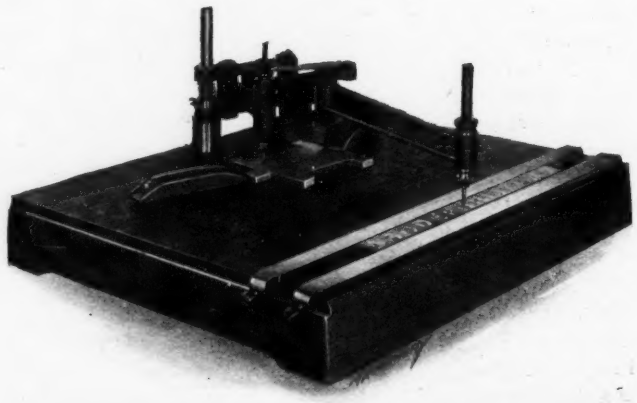
in the tank to drop to 120 pounds per square inch, the automatic switch starts the "lectroflater" again and brings the pressure back to 150 pounds per square inch and stops. Thus there will always be free air on tap, and plenty of pressure.

The "lectroflater" has no exposed mechanism, electrical or mechanical, so that it is impossible for anyone to be injured through coming in contact with moving armatures, gears, rods or shafts. These parts are enclosed and run in grease, which practically eliminates chance of accident and reduces wear to the minimum. A cover is furnished for the automatic switch on the right, completely enclosing all mechanical parts. All reciprocating parts are so accurately balanced that there is no vibration or pounding. This is the secret of long life in any machine. The lubrication of the "lectroflater" is entirely automatic, and it only requires repacking with grease about four times a year. This can be done in five minutes by the removal of a small plate and one grease cup. There is no expensive lubricating oil to buy and no danger of the outfit running dry and ruining itself on account of inattention. The cooling system is entirely automatic and requires no attention; and it has no liquid to freeze or evaporate. The automatic switch requires no attention and the large gage shows the exact pressure in the tank at all times. An automatic safety valve forms part of the outfit, as well as a drain cock for drawing off condensation at the under side of the tank.

The "lectroflater" system is so designed that in case an accident should happen to the compressor unit or the switch unit, either can be removed in five minutes by unscrewing one union and the base screws, and disconnecting two wires. The disabled unit can then be repaired and replaced with another. Universal motor windings will run on 110 volts direct current or alternating current of from 25 to 60 cycles. An outfit is also made with 220-volt windings. Length of outfit is 44 inches; width, 16 inches; height, 31 inches; weight, 140 pounds.

## WASHINGTON ETCHING MACHINE

The distortion resulting from the use of hardened steel stamps for marking gages and other forms of measuring tools or delicate instruments is generally recognized among machinists and toolmakers. The etching machine illustrated



Washington Etching Machine for marking Fine Tools and Gages

herewith is designed for marking all sorts of fine tools which might be injured by the use of stamps. A suitable resist is applied to the surface of the hardened tool and the machine is used for tracing the letters or designs required, which are afterward cut into the surface by applying an etching fluid. The machine operates on the pantograph principle. It is equipped with metal matrices or copy blocks which can be arranged like type in any desired combination of letters or figures.

In use, the stylus is guided by these matrices and the tracing point reproduces the lettering or figures on a smaller scale. The pantograph mechanism gives a reduction of 4 to 1 so that if ⅛-inch characters are required on the work, matrices with ½-inch face are necessary. The part to be etched is held in position on the table of the machine by the clamps shown, and the matrices are held in proper alignment by two parallel strips or bars, as the illustration shows. This machine is the product of the Spicer Tabulating Machine Co., 3318 Volta Place, N. W., Washington, D. C.

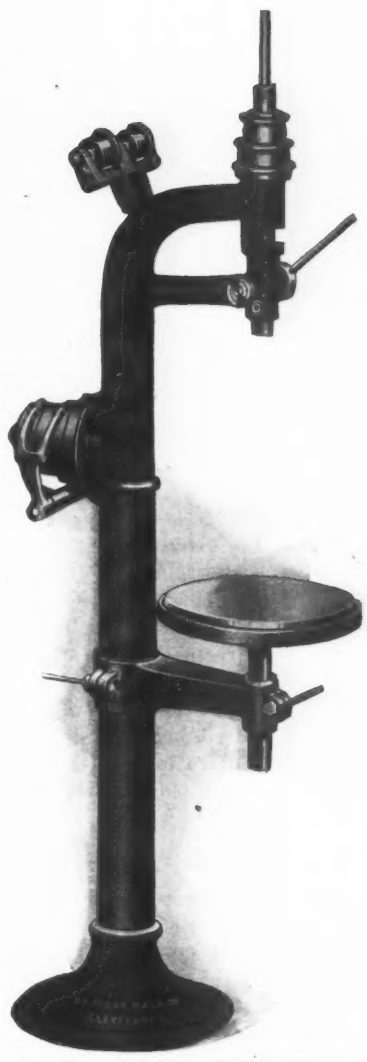
## BUCKEYE PORTABLE FILE SHARPENING MACHINE

The Macleod Co., of 2232-2236 Bogen St., Cincinnati, Ohio, has brought out a file sharpening machine which is a portable self-contained unit that may be operated either by steam or compressed air. The file to be cleaned or sharpened is held at a fixed angle by suitable guides and is acted upon by a blast of either air or steam carrying in suspension an abrasive material. A few strokes of the file in each direction are all that is required. The air or steam pressure should vary from 80 to 150 pounds per square inch, the higher pressure giving a much better cutting action than the lower pressure. The abrasive is a special flint, which may be used repeatedly or as long as it possesses any cutting qualities. A water jet is used in the nozzle which prevents the file from becoming overheated and also prevents the formation of dust. When the abrasive is too small or light for service, it flows away with the surplus water through the overflow. After the abrasive is discharged against the file, it falls into a lower hopper and is then drawn up again to the operating nozzle by the suction of the air or steam, as the case may be. This apparatus may also be used as a sandblast for cleaning small castings, there being a hand-hole in the rear of the upper hopper through which articles may be inserted for cleaning.

Buckeye File Sharpening Machine, which may be operated either by Steam or Compressed Air

## DEMOOY DRILLING MACHINE

In the October, 1916, number of MACHINERY a description was published of a sensitive bench drilling machine that had been placed on the market at that time by the DeMooy Machine Co., 1833 E. 55th St., Cleveland, Ohio. This firm is now manufacturing a drilling machine of essentially the same design except that it is provided with a stand, as illustrated, to adapt it for use as a floor machine instead of setting it up on the bench.



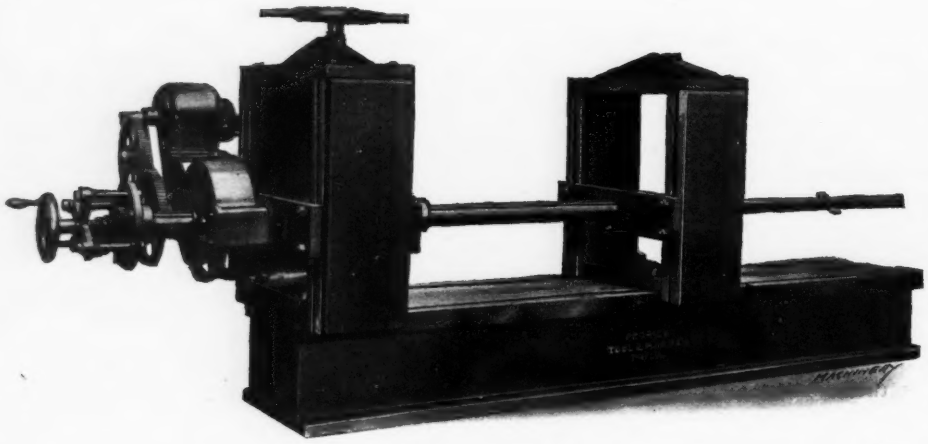
Floor Type of Sensitive Drilling Machine made by DeMooy Machine Co.

The principal dimensions of this machine are as follows: maximum distance from spindle to table, 37 inches; maximum vertical movement of spindle, 4 inches; maximum vertical movement of table, 7 inches; maximum vertical movement of sliding arm, 27 inches; diameter of table over oil groove, 11½ inches; distance from center of spindle to frame, 7½ inches; drilling capacity, for holes up to ½ inch in diameter; size of tight and loose pulleys, 5 inches in diameter by 1⅝ inch face width; speed of driving pulley, 350 revolutions per minute; height of machine, 64 inches; floor space occupied, 26 by 15 inches; and net weight of machine, 190 pounds.

## PEDRICK HORIZONTAL BORING MACHINE

The possibilities of the horizontal boring machine recently placed on the market by the Pedrick Tool & Machine Co., 3639 Lawrence St., Philadelphia, Pa., for performing boring and drilling operations and work of a similar nature are well shown by the illustration presented in connection with the following description. Several inherent features of this company's portable cylinder boring-bar have been incorporated in the present design, and this has resulted in the production of a universal boring machine having a range for handling a great variety of work. It consists of a heavy bed to which are fitted two housings that are movable to suit conditions. T-slots are provided on both sides of the housings by means of which the bar supports are held in position at the required height above the bed. The main bearing for the boring-bar is a long quill with cross-heads at both ends which are bolted to the front housing on both sides. The quill is bored to fit the bar, and the cross members are faced from the bore so that proper alignment is insured for any setting. A handwheel shown in the illustration operates the elevating screw for raising or lowering the bar to the desired position.

For shops which prefer to use individual electric motor drive, a motor may be connected to the drive as shown in the illustration. The main gear is divided and the teeth in one part are opposite the spaces in the other part of the gear, thus imparting a smooth motion without appreciable backlash. Gearing from the motor to the drive is variable, and the motor



Horizontal Boring Machine built by Pedrick Tool & Machine Co.

may also be connected to either the primary or intermediate shafts of the drive, so that various speeds are readily obtainable for boring holes of different diameters. At the end of the bar there is a feed case which is automatic in action and provides three changes of feed. The boring-bar has a feed-screw in a recess on one side, thus permitting much longer traversing feed than the conventional traveling bar affords. Quick return of the bar is made possible by removing the half feed-nut and sliding the bar through the bearing. In the end of the bar there is a taper hole in which auxiliary bars or drills may be fitted for boring holes of smaller size than the main bar. Fitted with a main boring-bar three inches in diameter, this machine will bore from the smallest hole up to a hole six inches in diameter, and an important feature is that the bar may be used as a traveling bar or as a fixed bar upon which the cutter-head travels. Both of these movements are accomplished by the same mechanism, thus providing for handling a wide range of work.

If the hole being bored is large enough to be conveniently handled by the main boring-bar, the work is set up on the bed, and the bar with a proper sized cutter-head on it is fed through the hole and through the bearing on the back housing, so that the bar is rigidly supported at both ends and the cutter-head travels along it, boring the hole to the required diameter. If the hole being bored is smaller than the main bar, it is necessary to use an auxiliary bar, and in such a case the main bar travels and feeds the smaller one. It will be apparent from the illustration that very little mechanism is required to make a horizontal boring machine of unusual capacity, which is capable of producing accurate work and will machine a wide range of parts. For instance, the machine illustrated is used to bore holes in large machine castings, the diameters ranging from 2½ to 6 inches and lengths from 24 to 36 inches, but these sizes do not represent the total range of the machine as regards either length or diameter. A table may be placed at right angles to the bed and provided with a cross-slide to adapt the machine for handling various classes of work which would not otherwise come within its range.

## BLEVNEY FINISHING MACHINE

The accompanying illustrations show a Type F two-belt 6- by 14-inch finishing machine with a turret attachment for finishing flat surfaces that has recently been placed on the market by John C. Blevney, 209 Parkhurst St., Newark, N. J. Fig. 1 shows a machine with a turret attachment for finishing lock-fronts while secured to the lock, hinges, striking-plates, sash-lifts, escutcheon plates and planer blades; in another factory it surfaces all kinds of cutting dies, etc. The machine is of the Blevney two-belt system, having a cushion belt running over two pulleys, with an abrasive belt running above this and over a third pulley, held under proper tension by levers *A*. The new feature is a platen *B* formed of bars, between which bars move freely up and down hardened mortised platen blocks *C*, Fig. 2. These platen blocks are separated from one another by platen block separators *D*, and the blocks and separators are locked in position by the platen lock *E*. The platen blocks *C* have projections at the top against which a rubber cushion *F* presses. The projections are of a predetermined size in relation to the other end or contact surface.

The rubber cushion *F* is placed over these blocks, and over this goes the rubber cushion holder *G*. The pins provided on this are for the purpose of holding the weights *H* which are required to provide grinding pressure. A lever *I* when in the position shown in Fig. 1 holds the platen from contact with the belts, and so stops grinding or finishing; when in the position shown in Fig. 2, the platen is acting upon the belt. Platen *B* is reciprocated by the crank *J*, Fig. 1, which is adjustable so as to give more or less reciprocation, according to the requirements of the work. It will be seen that with the belts resting on the work, the platen blocks, under pressure of the weights pressing through the rubber cushion, will cause the belts to conform to the irregularities in shape of the work; because of the rubber cushion, the belts press harder on the high points of the work than on the low points, so that in the grinding action the high points are cut down, while the low points are less affected. This action is increased by the reciprocation of the platen, and may be compared with an operator trying to find the high and low places while finishing work on a wheel.

Below the belts there is a side oscillating table *K*, the oscillations of which are adjustable by crank *L* as to length, and by screw *M* for centering in relation to the belts. On this plate is placed turret *N*, the face of which is H-shaped, and its bar extensions have holes. The two tables *O* are provided with pins which register with the holes in the turret. These tables *O* have other holes which serve to hold, with corresponding pins, the work-holding plate *P*. Work-holder *P* may be provided with pins or bars to hold the work from sliding sideways; and the belts hold it down on the plate.

In setting the machine, place the work on holder *P*, have stop *I* in the position shown in Fig. 1, rotate the turret to

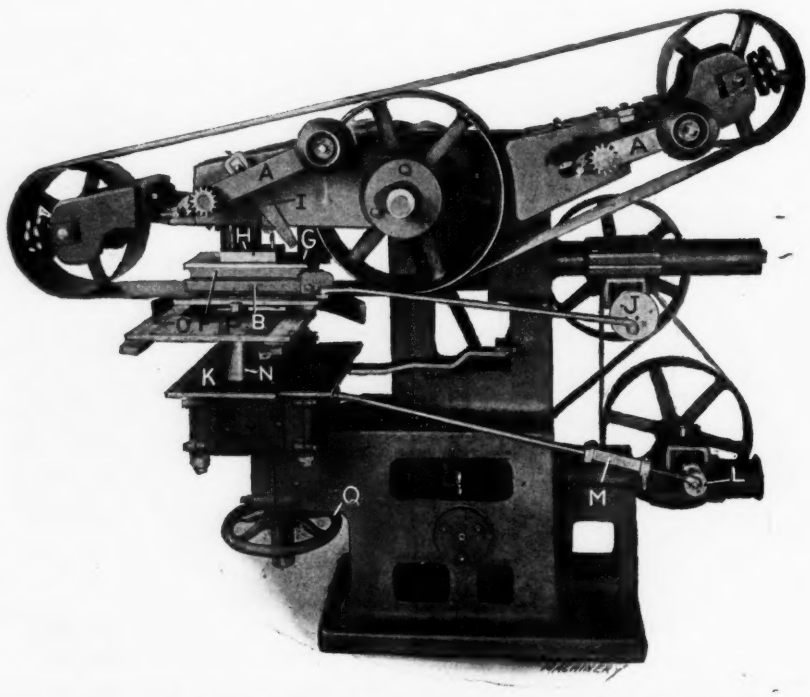



Fig. 1. Type F 6- by 14-inch Finishing Machine made by John C. Blevney

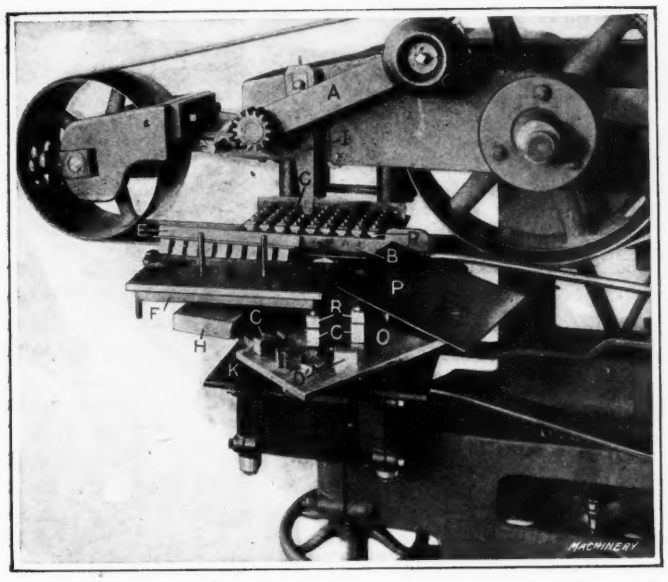



Fig. 2. Close View of Mechanism of Blevney Finishing Machine

bring the work under the belts, allow stop *I* to assume the position shown in Fig. 2, adjust by means of setting wheel *Q*, Fig. 1, so that the work will press the belts and the platen blocks upward until the upper edge of the mortise *R* on block *C* will have the proper limit finishing distance in its relation to the adjoining bar of platen *B;* in other words, limit the descent of these blocks. When the upper edge *R* of the mortise in block *C* and the adjoining bar is in contact, no further finishing can take place. For rough work, it is only necessary to have stop *I* in the position shown in Fig. 1, with the belts under tension, when the surface of the work to be finished is moved by wheel *Q* to within ⅛ inch of the belts.

In operation, place the work on holder *P* and bring stop *I* as shown in Fig. 1; swing turret to bring the work under the belts, and allow stop *I* to drop as shown in Fig. 2; fill up the second holder *P* with work, manipulate stop *I* as before, swing the work under the belts, allow stop *I* to assume the position shown in Fig. 1, take off finished pieces and reload and proceed as before.

## ANDERSON DIE MUZZLING MACHINE

One of the most difficult operations in the manufacture of threading dies is that known as "muzzling." This consists of beveling the first two or three threads of the die in such a way as to secure a clearance, so that as the die is fed onto the work it will cut without dragging. This clearance is similar to that on the end of a machine reamer, though the clearance is internal in the die and the opposite in the reamer. The muzzling operation is usually performed by hand with a small file and requires considerable skill.

In the development of the machine shown in the accompanying illustrations, the Anderson Die Machine Co., 590 Water St., Bridgeport, Conn., has endeavored to eliminate hand work on this particular operation. This firm's form of "super-helical" cutter has made it possible to machine the delicate threaded cutting edges without raising a burr. The cutter is made to represent a cone, being pointed toward the end; the angle of the side of the cone depends on the number of threads to relieve or back off; as, for example, a cutter with an angle of 30 degrees on the side will machine a clearance of about two and one-half to three threads, whereas a cutter with an angle of 45 degrees on the side will form a clearance on one and one-half thread only. It is usual in making dies, to back off one side more than the other; that is, three threads are backed off on one side and one and one-half on the opposite, so that the die can be used for threading long rods when it is not important to cut close to a shoulder; and then by reversing the die, threads can be cut close to a shoulder or extension.

The machine in the main consists of a hollow vertical spindle mounted on a frame and running in S. K. F. ball bearings. The chuck for holding the cutter is a split collet, so that the cutter will run true under all conditions. On the spindle is mounted a friction member which is driven by means of a spherical faced disk mounted on the armature shaft of the motor. The motor is pivoted in the frame of the machine in such a way that by tilting it the speed of the cutting tool can be varied to suit dies of various diameters. The spindle can be locked by means of a bolt at the side or front of the machine, so as to enable the operator to fasten the cutter securely in the chuck or collet; and a sleeve or draw-bar having a knob or handwheel at the top of the machine operates the chuck mechanism. This is quite similar to the draw-bar used in ordinary bench lathes.

The table is rectangular and provided with a crosswise slot into which the fixture is secured. The fixture consists primarily of two slides that permit adjustment in all directions, making it possible not only to operate on large as well as small diameters, but also to vary the amount of clearance on the cutting edges of the die. On the upper slide of this fixture is located a pivoted finger mechanism that is also adjustable. This index finger locates the cutting edge of the die in the right relation to the cutter. The finger is pressed down by a spring into the die openings and rests with a slight tension on the top of the die; it is so constructed that the die can be rotated under the finger from one cutting edge to the other. This does away with the necessity of removing the die or raising the finger, so that the die can be turned under this spring finger from one cutting edge to the other, making it a rapid operation. The part of this finger which engages the die can be removed and as many shapes and forms of fingers as necessary can be made and applied by inserting in a holder.

The table is mounted on a square quill, the lower end of which is turned and a fine thread chased thereon. On this threaded part are two knurled nuts, which come in contact with the lower face of the adjustable knee that carries the quill or table spindle. The table is raised and lowered by means of a foot-treadle mechanism which is located at the lower right-hand side of the pedestal. The rods connecting

Fig. 1. Die Muzzling Machine made by Anderson Die Machine Co.

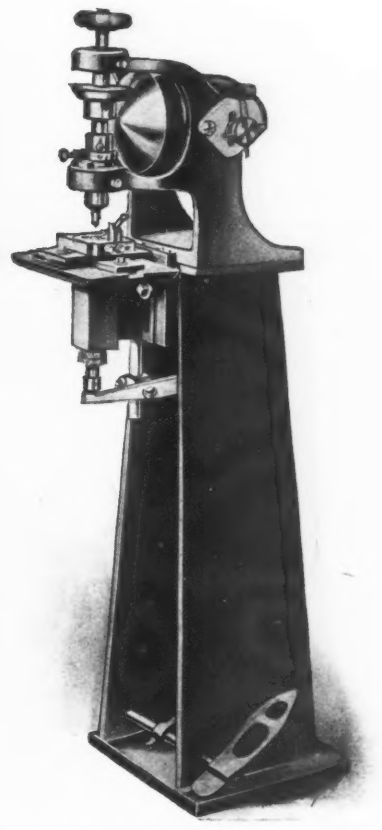


Fig. 2. Opposite Side of Machine shown in Fig. 1

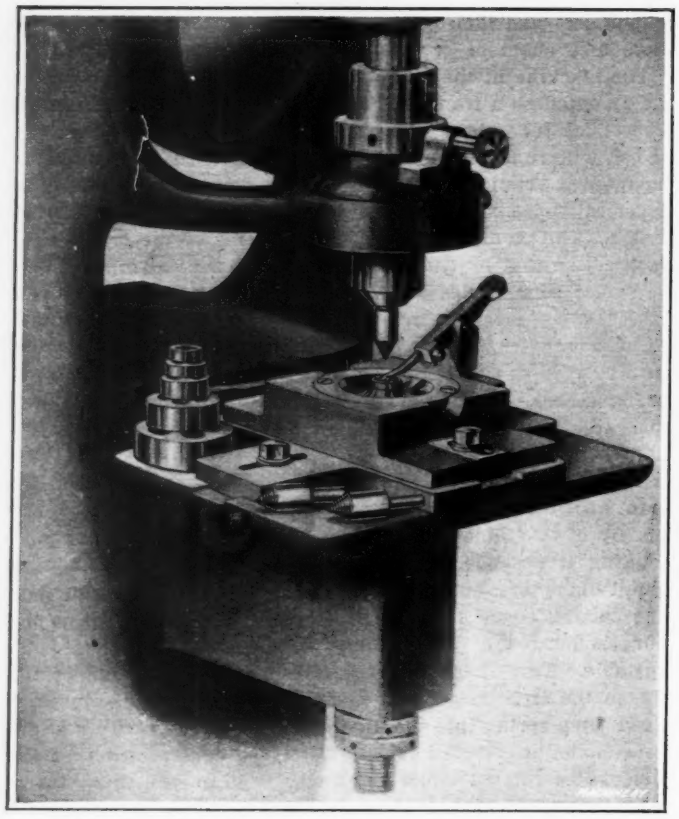


Fig. 3. Close View of Anderson Die Muzzling Machine in Operation

the foot-treadle and lever which operates directly on the end of the quill or table spindle are made adjustable, so that the whole mechanism can be readily adjusted to suit the operator's convenience. If necessary, a safety spring device can be introduced between the foot-treadle and the table, so that, regardless of the pressure applied by the operator on the foot-treadle, the pressure on the table spindle will be uniform. Any make of motor not exceeding 6 inches in diameter can be applied to this machine, 1/6 horsepower, 1700 revolutions per minute being ample for the operation. A switch is conveniently located for starting and stopping the machine, and a cord with attachment plug is provided so that the machine can be run from an ordinary lamp socket.

## "NATCO" STRAIGHT-LINE DRILLING MACHINES

The National Automatic Tool Co., Richmond, Ind., has recently added to its line of multiple-spindle drilling and tapping machinery three sizes of "straight-line" drilling machines, which are illustrated and described herewith. The design of these machines embodies many features that provide for efficient operation and rapid production. For instance, the machines may be equipped either with or without the "Natco" patented mechanism to provide for independent changing of speeds in the rail, which permits of drilling large and small holes simultaneously at the proper speeds and affords a neutral position for all spindles that are not in use. The machines that have independent change of speed are provided with a full complement of upper joints, whether or not there is need for as many drill spindles as the full number that can be carried in the rail.

Provision is made for a three-inch in and three-inch out adjustment of the drill spindles, thereby giving a drilling area six inches wide by the full length of the rail. All spindles are provided with a two-inch vertical adjustment to compensate for tools of uneven length or for uneven wear of tools. The minimum center distance is the diameter of the spindles plus 1/16 inch, which makes it possible to drill holes very close together. The machines may be equipped with a tapping attachment; a spot-facing attachment which is a new feature of the "Natco" drilling machines and permits of multiple spot-facing; a lubricating system for lubricating the work; and either belt or individual motor drive, in the latter case a five- to seven-horsepower motor running at 1800 revolutions per minute being used.

Fig. 1 shows what is known as the No. 39 machine, which

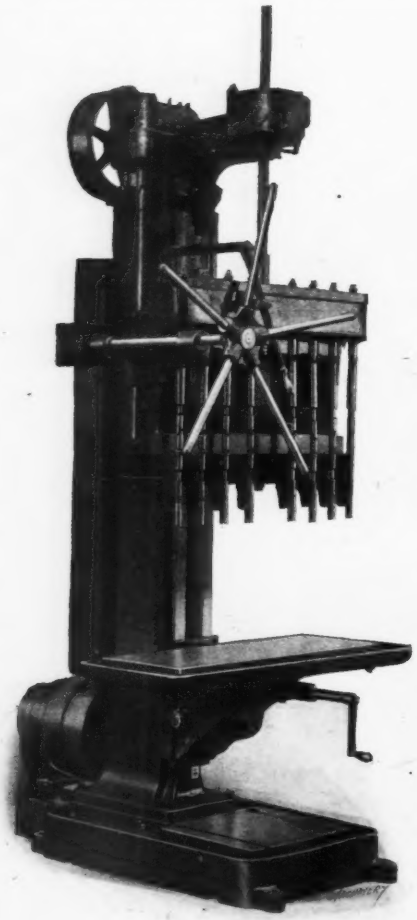


Fig. 1. "Natco" No. 39 Straight-line Drilling Machine

Fig. 2. "Natco" No. 40 Straight-line Drilling Machine

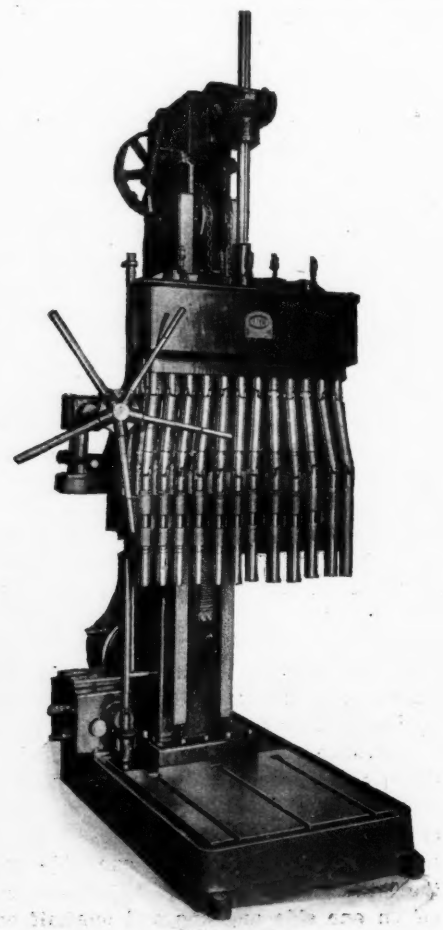


Fig. 3. "Natco" No. 41 Straight-line Drilling Machine

Lathe manufactured by the Master Machine Works

is equipped with a rail either 24 or 36 inches in length. The 24-inch rail is bored for a maximum of twelve spindles, and the machine with the 36-inch rail may be provided with as many as sixteen spindles. Six changes of speed are available on this machine, covering a range of from 363 to 1188 revolutions per minute. These speeds may be obtained as six single or three double speeds, in which the ratio of low to high speed is 2 to 1. The rate of feed in inches per minute varies from one to six, three feeds being obtained through a gear-box located on top of the machine. The capacity for drilling cast iron is twelve ½-inch holes or their equivalent, or twelve ⅝-inch cored holes. The driving pulley is 14 inches in diameter by 4 inches face width and is mounted on Hyatt roller bearings. The countershaft runs at 600 R. P. M. On this machine the maximum distance from the top of the table to the bottom of the drill spindles is 31 inches, while from the base to the bottom of the drill spindle the maximum distance is 49 inches. The area of the working surface of the table is 20 by 40 inches; the floor space occupied by the belt-driven machine is 63 by 61 inches; the floor space occupied by the motor-driven machine is 63 by 80 inches; and the weight of the machine is 4200 pounds.

The machines shown in Figs. 2 and 3 are known as the "Natco" No. 40 and No. 41 drilling machines, respectively, and it will be seen that they are of very similar design. The No. 41 machine is slightly heavier and more powerful than the No. 40. The latter is equipped with either a 26- or 32-inch rail and is bored for a maximum of either six or eight spindles; while the No. 41 machine has either a 32-inch rail bored for eight spindles, or a 48-inch rail bored for twelve spindles. Both of these machines are furnished with six changes of feed which are independent of the speeds, the rate of feed covering a range of from ¾ to 4¾ inches per minute, while six changes of speed are available, ranging from 128 to 525 revolutions per minute. The six changes may be obtained as six single speeds or three double speeds, and the ratio of low to high speed is about 2 to 1. The drill spindles are provided with a heavy ball thrust, and the spindle bearings are lined with bronze.

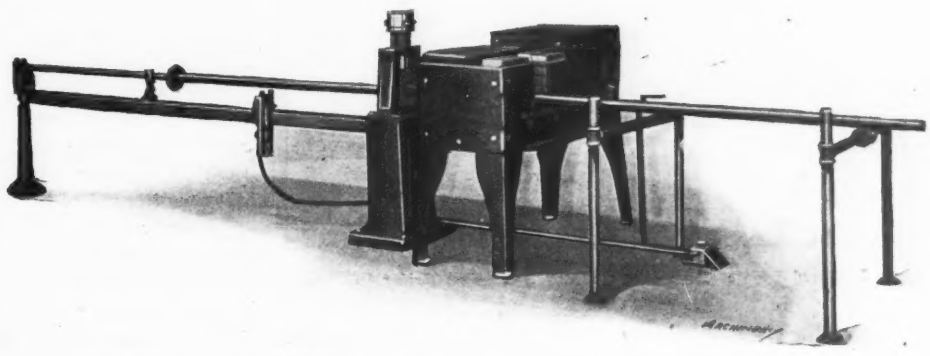
The drilling capacity of the No. 40 machine in cast iron is up to eight 1-inch holes or eight 2½-inch cored holes, while the No. 41 machine has a capacity of drilling in cast iron up to twelve 1-inch holes or twelve 2½-inch cored holes. The No. 40 machine is provided with a 30- by 32- by 20-inch box table, or with an adjustable table 29 by 42 inches in size; and the No. 41 machine is furnished with a 30- by 42- by 20-inch box table, or an adjustable table 29 by 42 inches in size. Both of these machines are equipped with tight and loose pulleys 16 inches in diameter by 5¼ inches face width, which run at 650 revolutions per minute. On the No. 40 machine the maximum distance from the top of the base to the bottom of the spindles is 32 inches, and on the No. 41 machine the corresponding distance is 46 inches. The floor space occupied by either machine when equipped with belt drive is 66 by 86 inches, and when equipped with motor drive, 66 by 107 inches. The weight of the No. 40 machine is 7500 pounds, and the No. 41 machine weighs 10,000 pounds.

## MASTER 12-INCH ENGINE LATHE

The Master Machine Works, 110 W. 40th St., New York City, are now manufacturing a light lathe intended for tool-room use as well as for general manufacturing operations. The headstock is of the all-geared design, and six spindle speeds are available, ranging from 28 to 418. These speed changes are controlled by means of two levers located on the headstock, and the arrangement is such that no two speed combinations can be engaged simultaneously. The carbon-steel spindle is provided with phosphor-bronze bearings and has a hole through it of ample size to accommodate a draw-in attachment and collets. The lead-screw is splined for the driving worm which operates the automatic cross and longitudinal feeds. The cross-feed screw has a micrometer collar graduated to read in thousandths inch. The lathe has a geared feed-box for obtaining rapid changes when turning or thread cutting. The actual swing over the bed is 12 inches and over the carriage 6½ inches.

## RYERSON BOILER TUBE RECLAIMING MACHINE

Joseph T. Ryerson & Son, Chicago, Ill., have recently added to their line the boiler tube reclaiming machine here illustrated and described. This equipment is intended for use in railroad shops and provides for the utilization of short boiler tubes which would otherwise be scrapped. The machine provides for welding such tubes together in order to make pieces of the proper length for use in locomotives. This equipment comprises a special pneumatic flue welding machine provided with an extension mandrel, an oil burning furnace, straightening and storage rack, automatic operating valves, etc. The entire outfit is of simple construction, and there is no intricate mechanism to complicate the method of operation; in addition to its use in reclaiming short pieces of tubing, this machine may also be employed for ordinary safe-ending operations. As regularly furnished, the machine is provided complete with one size of welding die and mandrel; and the oil burning furnace is equipped with a burner and completely bricked ready



Boiler Tube Reclaiming Machine built by Joseph T. Ryerson & Son

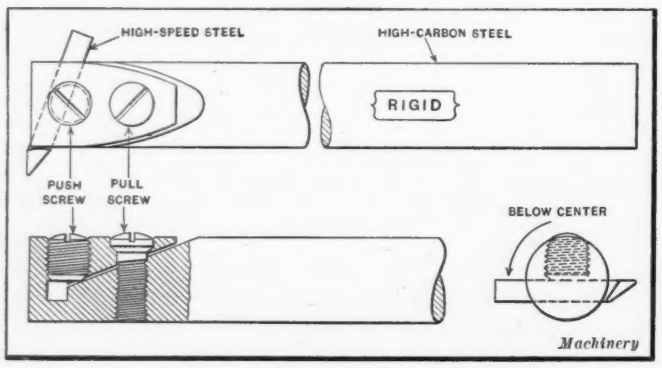
for service. Special machines may be furnished for any special class of work.

Until recently the reclaiming of old boiler tubes had been given little consideration by the railroads, owing to the fact that the reclamation of old materials in general had not received much attention. Another reason for this condition is that while machines were available for the performance of common safe-ending operations, there were no satisfactory machines for handling longer pieces of tubing. The safe-ending process was often carried to such an extent that not infrequently five or six and sometimes more pieces were welded to a tube used in a high-pressure boiler. When safe-ending is carried to such an extent the remainder of the tube is generally not worth reclaiming after the last removal from the boiler. More stringent regulations of the Interstate Commerce Commission, coupled with the wide "safety first" movement, have done much to improve this class of tube welding, and the number of safe ends that are pieced onto a tube is generally less than was the case a few years ago. As a result, a great many railroad companies have a large number of short tubes which are in good condition and can be used, provided they can be properly welded together to make suitable lengths with not more than one or two welds. It is for the reclamation of such pieces of tubing that the new Ryerson machine was developed. In operation, the tube is heated and belled out in the usual way and the safe end of the tube inserted. The tube with the safe end inserted is then passed through the furnace and over the mandrel until the point to be welded is in the proper place for heating in the furnace. When the desired temperature has been reached, the tube is shoved forward through the furnace until it reaches the desired position in the welding die, the welding machine being in direct line with the furnace.

This machine is of the hammer type and a stop or guide is arranged on the mandrel which acts as a gage to locate the welding point under the die as well as an automatic starting device for the welding machine. When the farther end of the tube strikes this stop or guide, it operates a lever that, in turn, opens the air valve on the welding machine, thus permitting entrance of air into the cylinder. As soon as the pressure of the tube is taken off the gage stop, the air supply is cut off and the welder is stopped. Afterward the tube is pulled back through the furnace and the operation is completed. The principal dimensions of the welding machine are as follows: capacity for handling tubes from three to six inches in diameter; floor space occupied, 30 by 30 inches; and weight of machine, 800 pounds. The principal dimensions of the furnace are: capacity for handling tubes from three to six inches in diameter; floor space occupied, 3 feet, 5 inches by 5 feet, 6 inches; and weight of furnace, 2250 pounds.

## RIGID BORING-BAR

The Rigid Tool Holder Co., 149 Carroll St., S.E., Washington, D. C., is now manufacturing the tool shown in the accompanying illustration. This is known as an improved lever-

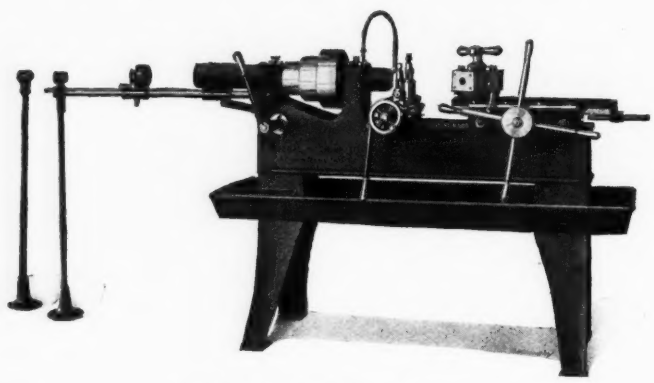



Improved Type of Boring-bar made by Rigid Tool Holder Co.

clamp boring-bar and was developed by the firm's manager, E. F. Gibbs. The important features of this tool are its simplicity, the liberal amount of power provided for clamping the cutter, the fact that it is unnecessary to use special wrenches, and the position of the cutter below the center of the boring-bar, which reduces the tendency for the tool to dig into the work.

## FEDERAL PLAIN-HEAD SCREW MACHINE

A machine known as a No. 3 or 14-inch plain-head screw machine has recently been placed on the market by the Federal Machine Co., 1602-1618 S. Lafayette St., South Bend, Ind. It is equipped with an automatic chuck and bar feed and will handle the following sizes of bar stock: round, up to 1 15/16



Federal Plain-head Screw Machine

inch in diameter; square, up to 29/32 inch; hexagonal, up to 1⅛ inch. All sizes of stock are handled by means of an automatic chuck and tool-steel spring collet. It will be seen that this machine is driven by a three-step cone pulley which has steps 3½ inches in width, which provide ample power to enable the machine to take heavy cuts at high speed. The head and bed are cast in one piece to obtain the maximum strength, and the bed is designed with thick walls and closely spaced internal braces to further reduce the tendency for the machine to spring while taking heavy cuts. Further provision against trouble from this source is made by having a three-point bearing on which the machine rests, thus counteracting any twisting action due to an uneven foundation.

The spindle is made of high-carbon forged crucible steel bored from the solid and accurately ground to size. The spindle bearings are lined with phosphor-bronze, the front bearing being 5¼ inches long and the rear bearing 4½ inches in length. Six tool holes are provided in the faces of the turret, which measures 8¼ inches across the flats. Each hole is fitted with self-raising and self-aligning binders, and there are bolt holes for securing tools to the faces. The turret stud is a taper fit in the slide and revolves with the turret, provision being made for adjustment; it is claimed that this keeps the alignment of the turret accurate throughout the life of the machine. The lock bolt and lock bolt bushings in the turret and slide are made of tool steel hardened and ground to size. Bar stock can be fed through the turret, which obviates the necessity of removing the turret saddle in cases where it is required to cut off long pieces. By a reverse movement of the turret saddle turn slide, the turret lock bolt is automatically released and the turret revolves to the next station. Adjustable independent stops automatically operate for each position of the turret. The turret saddle is fitted with adjustable taper gibs for its entire length which provide means for adjusting the slide.

The cut-off is furnished with a combination lever and screw feed. A square jaw clutch cut in the hub of the lever is directly engaged with the pinion, which, in turn, meshes with a rack on the cross-slide. The lever may be brought into different positions by simply advancing or retarding the clutch. The screw is instantly engaged or disengaged by a small eccentric lever at the left-hand side of the cross-slide; this lever engages a hardened tool-steel lock yoke of the split nut type placed between two hardened and ground collars on the screw. These collars serve the additional purpose of providing a bearing for the screw in the slide, and the cross-slide has adjustable stops and a micrometer dial for fine adjustment. The

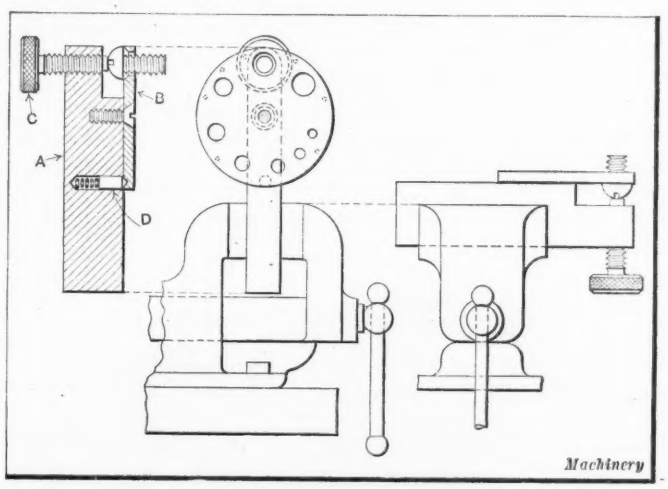
toolposts have adjustable wedges for raising or lowering the tools, and the cut-off can be removed from the bed without disturbing the turret saddle.

A Brown & Sharpe oil pump driven by a belt from the countershaft delivers an abundant supply of lubricant to the cutting tools and operates when the machine is running in either direction. The oil or chip pan is cast integral with the blocks supporting the bed, and the deep space under the bed from which the chips can be removed is a convenient feature. There is a drop of ½ inch from the rear end of the pan to the oil strainer located directly below the rear spindle bearing, thus insuring quick return of lubricant to the tank. which is cast in one leg and arranged so that it may be easily drained by simply removing a pipe plug from the bottom. In addition to the accessories shown in the illustration, the regular equipment of this machine consists of a double friction countershaft, tool tray, splash board, reversible oil pump, one hardened and ground collet, and the necessary wrenches for making all adjustments. A turret lathe is also made by the Federal Machine Co. which is of essentially the same design, except that it does not have an automatic chuck and bar feed, oil pan and pump. The end of the spindle is of sufficient length to allow for threading it for any standard air chuck.

The principal dimensions of this machine are as follows: diameter of hole in automatic chuck plunger, 1 5/16 inch; diameter of hole in spindle, 1 9/16 inch; maximum length of work that can be turned, 8 inches; maximum distance from end of spindle to turret face, 19 inches; swing over bed, 14 inches; swing over cut-off slide, 6½ inches; distance from center of turret holes to top of slide, 2¾ inches; diameter of turret holes, 1¼ inch; size of tapped holes in turret faces, 7/16 inch; diameter of countershaft pulley, 12 inches; face width of countershaft pulley, 4 inches; size of cut-off tools, ⅝ by 1¼ inch; floor space occupied, 2 feet, 3 inches by 7 feet; and net weight of machine, 1670 pounds.

## DUNCAN SCREW AND RIVET HOLDER

Toolmakers and machinists often experience difficulty in holding screws or rivets when the ends need to be filed or sawed off. The usual method is to clamp the head of the screw or rivet in a vise, but owing to the circular form of the head, the screw is not firmly held and there is likely to be more or less distortion of the head due to the clamping pressure of the jaws. The screw and rivet holder shown in the accompanying illustration provides a simple and effective method of holding screws or rivets without marring them. This holder, which has been brought out by John C. Duncan 204 E. North Ave., Pittsburg, Pa., consists of a shank *A* which is clamped between the vise jaws; a circular plate *B* containing holes of different sizes for receiving the screws or



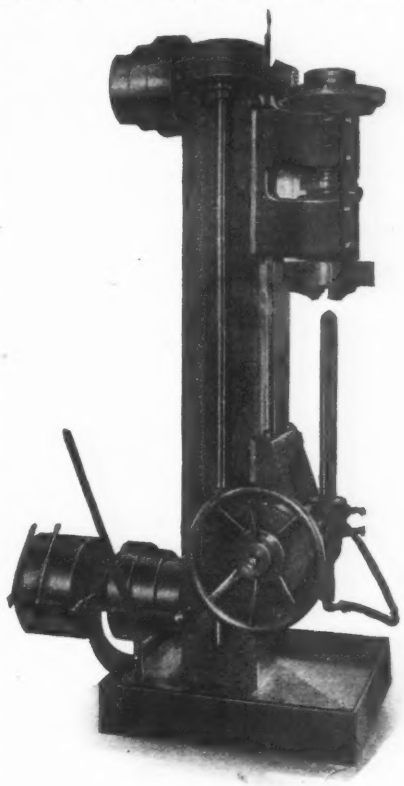

Duncan Screw and Rivet Holder

rivets; a clamping screw *C* for holding the screw to be operated upon firmly in position; and a small spring detent *D*, the end of which engages conical seats in plate *B* so that any one of the holes in this plate may readily be aligned with the clamping screw.

After a screw is inserted through one of the holes, the plate *B* is turned to locate the head opposite the clamping screw, which is then tightened. The holder can be secured between the vise jaws in any position that will be most convenient for the workman. The central view shows the holder in a vertical position, whereas the view to the right shows it in a horizontal position.

## STECHER SPINDLE DRILLING MACHINE

For use in drilling lathe spindles and for similar operations, the Charles Stecher Co., 1574-1580 Crossing St., Chicago, Ill., is now building a machine which is shown in the accompanying illustration. It will be seen that the drill is held in a vertical position and feeds up into the work, thus preventing the hole from becoming clogged with chips. A small force pump, which is included as part of the regular equipment, keeps the drill cool and free from obstruction. It will be seen that the machine spindle is furnished with a chuck at the lower end which is capable of holding all work that does not exceed 30 inches in length, but for longer pieces it is desirable to employ a chuck at both ends of the spindle.



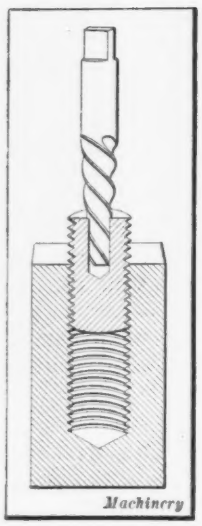
Spindle Drilling Machine made by Charles Stecher Co.

In drilling long holes, *i. e.*, those exceeding 24 inches in length, experience has shown that the drilling can be done much faster by working from both ends of the piece, because in this way the drill need only be slightly in excess of one-half the length otherwise required. With a feed of 0.005 inch per revolution of the work, holes 36 inches in length by 1 29/32 inch in diameter have been drilled in 35 minutes. These spindles were drilled from both ends, and the time includes setting up the work and removing it from the machine. The upper and lower horizontal shafts are provided with ball bearings and the main spindle is provided with a ball thrust bearing. The feed mechanism is so arranged that any desired feed can readily be obtained by means of removable gears furnished with the machine.

The principal dimensions of the machine are as follows: distance between face of chuck and drill-holder, 32½ inches; diameter of hole through spindle, 4¼ inches; swing over face of bed, 14 inches; diameters of cone pulley steps, 9½, 11½ and 13½ inches in diameter; face width of cone pulley, 3 inches; diameter of tight and loose pulleys, 14 inches; face width of tight and loose pulleys, 4 inches; speed of tight and loose pulleys, 450 R. P. M.; width of column, 12 inches; height of machine, 7 feet, 6 inches; diameter of steel scroll chuck, 12 inches; floor space occupied, 32 by 48 inches; and net weight of machine, 1800 pounds.

## CLEVELAND SCREW EXTRACTOR

Every machinist knows how difficult it is to remove the end of a set-screw or bolt which has broken off in the hole or below the top of the hole. In many cases the only method of removing the broken end is by drilling it out completely, which usually requires considerable time. The Cleveland Twist Drill




Cleveland Screw Extractor

Co., Cleveland, Ohio, has placed on the market a simple form of tool for removing broken screw ends, known as the "Ezy-Out" screw extractor. This extractor is sold in sets of three and is made in different sizes which are applicable to different classes of work. The principle upon which the extractor operates is indicated by the accompanying illustration. The gripping end is slightly tapering and has left-hand spiral ridges. When a screw is to be removed a hole is drilled in one end, into which the extractor is inserted. A slight twist seats it firmly in the hole and continued rotation to the left causes the left-hand spiral to grip the sides of the drilled hole, thus exerting an unscrewing action on the broken screw end, which is backed out on its own thread. If the screw should fit tightly or stick because of rust, the extractor grips it more tightly. With this method of removal there is no danger of injuring the threads in the hole, which is often done when the broken screw end is removed in the form of chips by drilling a hole through it from end to end. These extractors are made of a tough grade of steel and are specially treated to withstand the torsional strains to which they are naturally subjected.

## WILSON SYSTEM OF ELECTRIC WELDING

For use in repairing broken machine parts ranging from pieces of small size up to parts machined from heavy castings, the Wilson Welder & Metals Co., Inc., Vanderbilt Ave. and 45th St., New York City, has developed a system of electric welding. In addition to its application in the repair of broken parts, the Wilson system may be applied in the manufacture

Fig. 1. Welding Tool or Electrode Holder with Distant Control Switch

of such products as metal-cutting tools where a cutter of high-grade tool steel is welded onto a machine steel shank. By this method cast steel, cast iron, wrought iron, brass, copper, or any other weldable metal can be welded with satisfactory results. It is claimed for this system that the consumption of power is very low and that a material saving of labor is effected by having the control of the heat or amperage at the arc placed conveniently for the operator, so that he does not have to go back and forth between the work and control board when it is necessary to adjust the heat to meet conditions. Another important feature is that a number of welders can work from a single machine without one interfering with the work of another; power is located at one point, where it can have proper supervision, and it can be distributed to convenient points throughout the shop.

With this system of electric welding, the heat may be accurately controlled at the point of application of the metal, which insures obtaining welds of uniform quality. There is a critical temperature at which steel can be welded to give the greatest

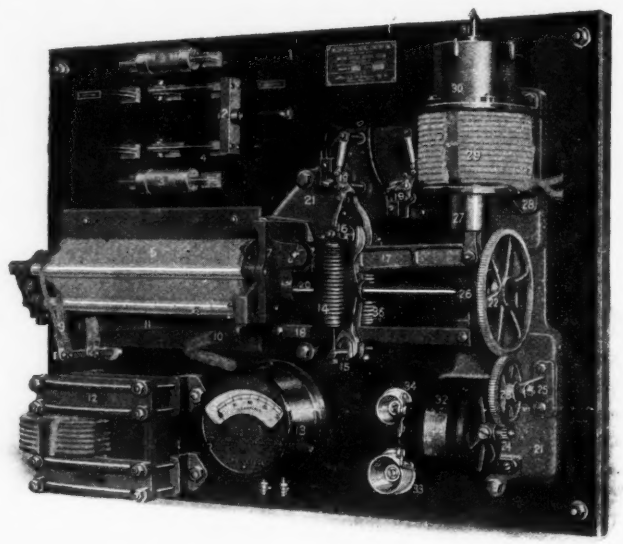


Fig. 2. (1) Slate Panel; (2) Double-throw Switch; (3) 300-ampere Fuse; (4) Switch Receptacle; (5) Carbon Pile; (9) Back End Disk Cable; (10) Front End Disk Cable; (11) Asbestos Board; (12) Choke Coil; (13) Ammeter; (19) Toggle Circuit Breakers; (27) Solenoid Plunger; (28) Solenoid Casting; (29) Solenoid; (30) Dash Pot; (31) Piston-rod to Dash Pot; (32) 1/10-horsepower Motor; (33) Welding Circuit Plug; (34) Control Circuit Plug

tensile strength and ductility, and by heating above this, a fracture of the welded section will show a segregation of carbon and slag, which naturally weakens the weld. If, on the other hand, the temperature is lower than the critical temperature, a fracture through the welded section will show that the metal has been deposited in globules with many open spaces between them, this being a fairly sure indication that the weld has been made at too low a temperature. With the Wilson system it is claimed that the heat at the arc does not fluctuate; therefore welds made are high grade and uniform.

Experience has shown that in order to secure satisfactory results in electric welding, the use of a proper grade of metal is of as great importance as having a properly designed machine. Recognizing this fact, the Wilson Welder & Metals Co. has developed specially prepared welding metals which are not adversely affected by the heat of the arc. These metals are used in the form of an electrode. This metal is a homogeneous alloy combined with an excess of manganese to compensate for losses while passing through the electric arc, thus insuring a substantial amount of manganese in the welded joint which is essential to its toughness. In addition, a

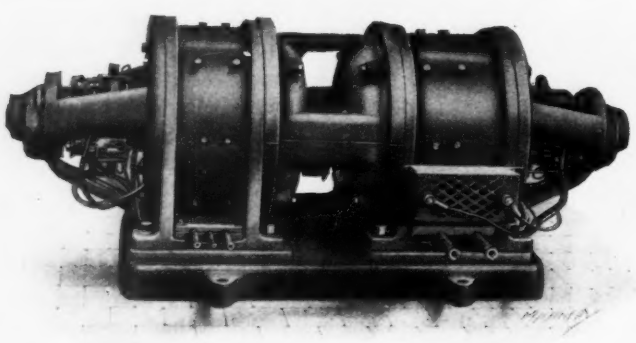


Fig. 3. Four-arc or 600-ampere Capacity Motor-generator Set for Direct Current

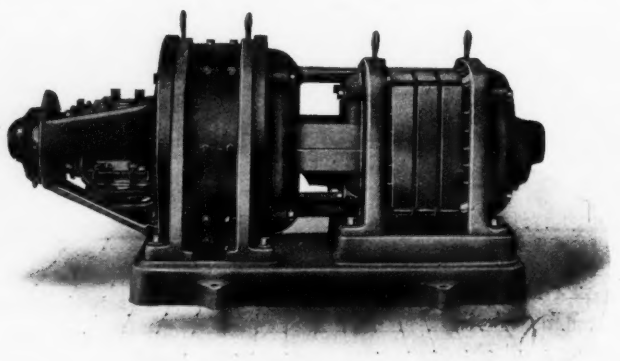


Fig. 4. Four-arc or 600-ampere Capacity Motor-generator Set for Alternating Current

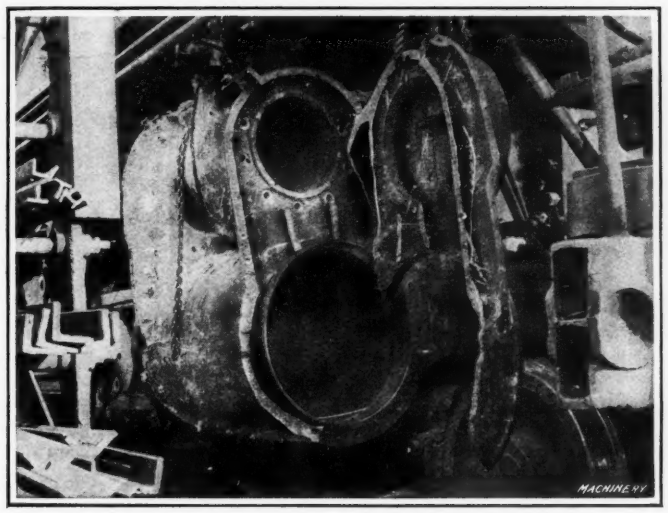


Fig. 5. Fractured Steam Chest and Cylinder on Locomotive to be welded

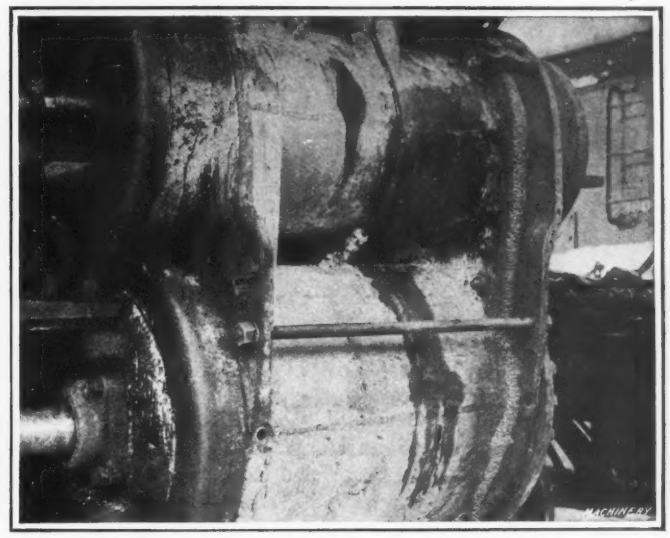


Fig. 6. View of Parts shown in Fig. 5 after being repaired with Wilson Electric Welder

manganese-copper alloy welding electrode has been developed, which is composed of iron homogeneously combined with such an excess of manganese and copper over the amount lost in the arc as will insure to the welded joint an additional degree of toughness and ductility, but leave it soft enough to be readily machined. Fig. 1 shows the welding tool or electrode holder provided with a distant control switch in which these special welding electrodes are held.

Fig. 2 shows the constant-current control panel for welding and cutting, provided for use in connection with the Wilson equipment, and in the caption are listed the more important parts, which may be readily identified by corresponding numbers which appear on the illustration and in the caption. The general function of this panel is to maintain a constant flow of current between the welding tool and the material operated upon, regardless of variations in the resistance of the welding circuit due to varying lengths of arc or other causes. The current regulator consists of a carbon pile held under compression by one or more helical springs, the pull of which is opposed by a solenoid through which the current to be regulated is passed. A suitable air dash pot is connected to the solenoid plunger to prevent all "hunting" or chattering due to the tendency of the plunger and connected parts to travel beyond the desired point. The pressure of the springs is transmitted to the carbon disks or plates through a lever, and the springs are mounted on a carriage in such a manner that the point at which they act upon the lever may be changed, thereby increasing or decreasing the leverage, as may be necessary. The position of the control solenoid in relation to the lever is fixed, and the movement of the spring carriage is produced by a small electric motor so wired that it may be controlled by two push buttons located at the welding tool or near enough to the welding tool so that the operator can use them without changing his position. The panel is also provided with a reactance coil of a size sufficient to assist the operator in maintaining an arc with a graphite pencil when the panel is used for cutting or burning away metal in preparing for the welding operation or for other purposes. An ammeter is provided to indicate the amount of current used in the welding process, and a double-throw switch of 200 amperes capacity is employed for changing from the welding to the cutting circuit.

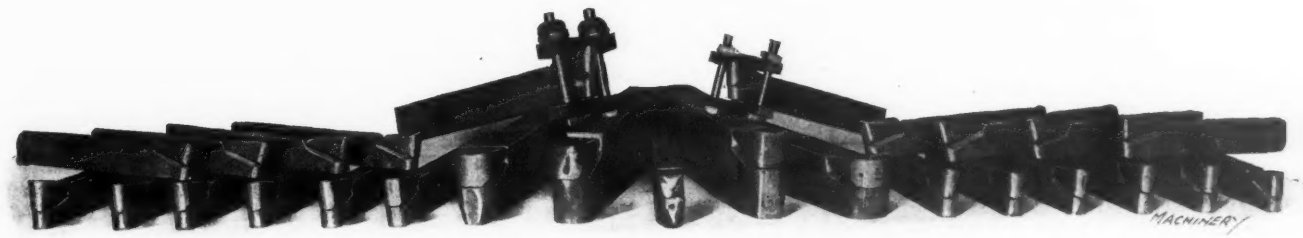


Fig. 7. Cutting Tools prepared for welding Points onto Shanks

In Fig. 3 is shown the Wilson arc welding motor-generator set, consisting of a direct-current compound interpole generator and an interpole direct-current motor. This machine is designed with especial reference to the intermittent nature of the load and is adjusted to operate with fixed brushes at any load from no load up to the maximum capacity of the machine. It will not show any tendency to flash when the maximum load is suddenly removed. The entire magnetic circuit of the generator is constructed of thin sheet-steel plates, castings being used only for mechanical and not for magnetic purposes, thus providing an exceptionally quick recovery coefficient and permitting the operation of more than one welding circuit from the generator without interference. It is claimed that commutation will be sparkless under all conditions and changes of load within the rating of the machine, and that the set will operate without excessive noise or vibration.

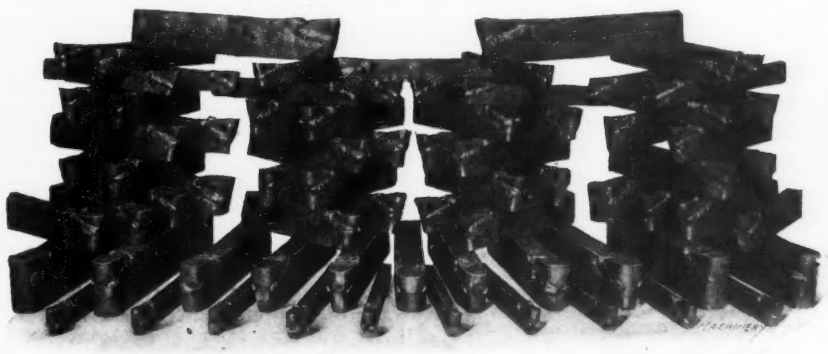


Fig. 8. Cutting Tools with Points welded onto Shanks

The outfit is mounted on a heavy cast-iron sub-base and provided with self-

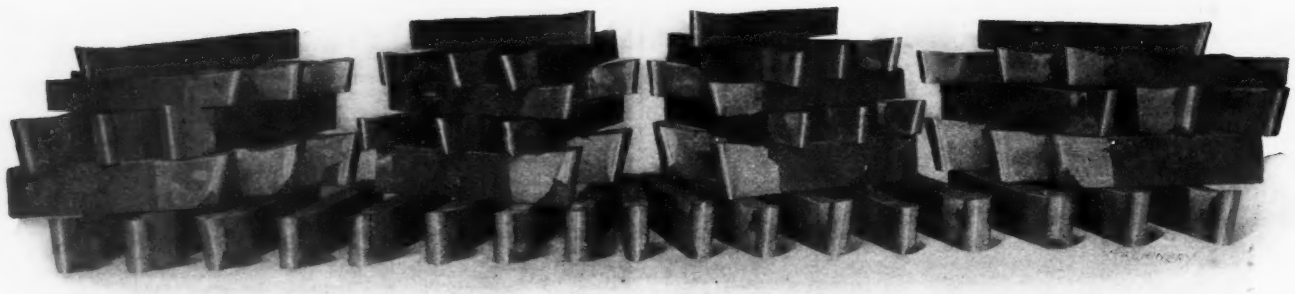


Fig. 9. Cutting Tools with Points welded onto Shanks after being ground Ready for Use

oiling bearings lined with hard babbitt. The rotors of both machines are mounted on a single shaft, which is made of high-carbon steel supported on two, three or four bearings. The bearing housings of the set are demountable to permit of easy removal of the rotors. Compensators equipped with no voltage release are furnished with each set. The fields of the direct-current generator and of the motor are of the ring type constructed of laminated steel, and the pole pieces are also built of laminated steel, bolted in place and so arranged that any field coil and its core may be easily removed. The field coils are form-wound without metal spools and thoroughly insulated.

Both machines are furnished with interpoles, one for each main pole on the machines, in order to provide for obtaining improved commutation and fixed brushes. The armatures are of the slotted drum type, having a core of thin sheet steel of high magnetic quality, each sheet being varnished to reduce core losses. The windings are formed coils or rectangular bars, thoroughly insulated. The commutators are built of hard copper bars, insulated with mica and rigidly held in place by heavy clamping rings. The brush-holders are of the radial type and fitted with carbon brushes; they have no sliding contacts which carry current. Particular care has been taken to provide ample facilities for ventilation by means of air ducts in the cores, so that free circulation is obtained through the cores and windings.

Fig. 4 shows the Wilson electric welding motor-generator set for alternating current, which consists of a direct-current compound interpole generator and a squirrel-cage polyphase induction motor. The general features of this outfit are the same as those described in connection with the direct-current motor-generator set. The stator core of the induction motor is built of punchings of thin sheet steel of high magnetic quality, each sheet being varnished to reduce core losses to a minimum. The core is rigidly supported by two heavy cast-iron clamping rings that form the frame of the stator. The windings consist of form-wound coils treated with insulating compound, after which they are taped, varnished and baked.

The slots of the winding of the six- and eight-arc machines are lined with insulating material, form-pressed coils being used in the smaller sized machines. The windings are securely held in place by wedges driven in between the tips of the core teeth, and the terminals of the winding are brought out so that connection to the power lines may be easily made. The rotor core is built from punchings of thin sheet steel, which are treated in the same way as those of the stator. The core is keyed to the shaft between clamp plates to prevent bending the end sheets. The rotor conductors are placed in partly closed insulated slots and securely riveted and soldered at both ends to short-circuiting rings. The periphery of the stator is entirely exposed to the air, and where necessary, ducts are provided in both the rotor and stator cores to permit thorough ventilation.

## NEW MACHINERY AND TOOLS NOTES

**Safety Goggles:** Chicago Eye Shield Co., Chicago, Ill. Goggles made of glass that resists splintering. Nails have been driven through the lens without shattering the glass, which is of American manufacture.

**Hydraulic Baling Press for Scrap Metal:** Logemann Bros. Co., Milwaukee, Wis. This press forms the metal scrap into compact bales. One ram forces the scrap into a flat shape and another, operating at right angles to it, produces the solid bales.

**Ball Bearing Grinder:** United States Electrical Tool Co., 6th Ave. and Mt. Hope St., Cincinnati, Ohio. This machine may be operated with either direct or alternating current. While it is provided with a knife switch located in the base, the push-button control will be furnished when desired.

**Twin Angle Compound Air Compressor:** Sullivan Machinery Co., Chicago, Ill. A compressor consisting of two units, each complete in itself, which are set side by side on a common foundation and are driven by a common shaft. Couplings at each end of this shaft permit either compressor to be cut out of service at any time.

**Twenty-six-inch Heavy-duty Engine Lathe:** Riter-Conley Co., Pittsburg, Pa. A heavy-duty geared-head engine lathe that, with a 16-foot bed, weighs 16,000 pounds. The spindle, which is 56 inches long, is made of high-carbon forged steel and runs in bronze bushings. The steel gears that provide the eight speed changes run in oil.

**Heavy Turret Lathe:** International Machine Tool Co., Indianapolis, Ind. This 26-inch lathe is adapted for both bar and chucking work. The gears that drive the spindle are located on each side of and close to the front main belt. The swing over the carriage is 24 inches, and both the toolpost and the turret carriages have a travel of 72 inches.

**One-man Shop Truck with Detachable Tongue:** Howe Chain Co., Muskegon, Mich. The special features of this truck are the large roller bearing wheels, which support the load to insure easy running, and a detachable jack tongue, with a small roller bearing lead wheel. A foot at the front of the truck takes the loads when the tongue is detached.

**Truck Side-rail Press:** Southwark Foundry & Machine Co., Philadelphia, Pa. A six-cylinder hydraulic press designed for forming the side members of automobile and motor-truck frames. It is built of steel castings and forgings and will handle two rails 175 inches long, of 5/32-inch stock, at the same time. The rate of operation is 100 strokes an hour.

**Eighteen-inch Heavy-duty Engine Lathe:** Carl G. Westlund Co., Worcester, Mass. This lathe is made with 8-, 10- and 12-foot beds, and has a swing of 20 inches over the bed; it will cut from three to twenty-four threads per inch, including pipe threads. It has double back-gears and a three-step cone pulley. A 14-inch lathe of the same design is made, but it has a single back-gear.

**Machine for Washing and Pickling Metal Goods:** Howard Iron Works, Buffalo, N. Y. This machine, which is designed to wash and pickle punchings, stampings, etc., is made in two types. Both require sixty pounds steam or air pressure to operate them. One type of machine has a capacity, in unbalanced loads, of 4000 pounds and the other machine will handle loads of 500 pounds.

**"Prestwich" Fluid Gage:** Coats Machine Tool Co., Inc., New York City. This instrument has a fixed and an adjustable anvil which are so placed, when set, that work of the correct size brings the fluid in the small tube to the level of the indicating pointer. A variation from this size causes a displacement of the anvils and a much greater displacement of the fluid in the tube.

**Vernier Height Gage:** L. S. Starrett Co., Athol, Mass. This gage consists of a bar graduated to read, by means of a vernier, to 0.001 inch on heights up to 8 inches, and a hardened base ground square with the bar. By means of a special attachment, measurements may be taken at the top or bottom sides of the gage, while the use of another attachment makes it possible to measure the depth of recesses or the inside of the frame of a jig, etc.

**Adjustable Fixture for Locating and Drilling Holes in Jigs:** Wadell & Bowen Co., Newark, N. J. This fixture consists of a table mounted on two slides at right angles to each other; it also has at its back a vertical post to which is fastened an arm. This arm is adjustable vertically and its outer end is bored for a drill bushing. The work is adjusted with relation

to the drill bushing by using length bars one inch thick and the micrometer screws in each slide.

**Light Tool-room Lathe:** Master Machine Works, New York City. A machine suitable for light manufacturing that requires no countershaft, as the belt passes directly from the main lineshaft to tight and loose pulleys on the headstock. The swing over the bed is 12 inches, and over the carriage, 6½ inches; the capacity between centers is 2½ feet. The six spindle speeds may be obtained by means of two controlling levers and the apron is arranged for screw cutting and has longitudinal and cross power feeds.

**Semi-automatic Thread Milling Machine:** T. C. M. Mfg. Co., Harrison, N. J. A machine designed primarily for milling threads on rifle barrels, fuse bodies, etc. This machine has cut in one hour the 14-pitch thread on 120 bronze primers 1/2 inch long and 1 3/16 inch in diameter. The work is held in a collet chuck operated by a hand-lever; the work-spindle is rotated by a worm and worm-wheel acting through a clutch that is automatically engaged by advancing the cutter into the work and is disengaged when the spindle has made a complete revolution and the thread is finished.

**Tilting Band-saw Machine:** J. A. Fay & Egan Co., Cincinnati, Ohio. This saw, while in operation, can be moved by power through an arc of 90 degrees, 45 degrees each side of the vertical. The exact angle at which the blade is tilted is shown by an index. The column is a massive one-piece casting with broad floor bases. Its face is planed and fitted with roller bearings and carries the saw carriage, guides, etc. A 48-inch square iron table is also rigidly mounted in this column. The mechanism for moving the blade is mounted upon an auxiliary column in the rear.

**Steel-jacketed Electric Heater Unit:** Cutler-Hammer Mfg. Co., Milwaukee, Wis. These units are used to heat crane cabs and warm the feet of shearmen and tablemen in steel plants. They may be used with either direct or alternating current of a voltage of 115, 230 or 250 and have a capacity of 500 watts. The nickel-chromium resistor, which furnishes the heat, is enclosed with mica, and this, in turn, is surrounded with a steel jacket. Each unit is 2 feet long, 1½ inch wide, and 3/16 inch thick. As no assembly of parts is required, the units can be installed singly or in groups.

**Cincinnati Automatic Bed-type Millers:** Cincinnati Milling Machine Co., Cincinnati, Ohio. The machines are designed for the quantity manufacture of such parts as enter into firearms, typewriters, etc. They are of the Lincoln type with the table supported directly on the bed without any saddle. The automatic features reduce the work to chucking new pieces, shifting the starting lever, and removing the finished work. The working surface of the table is 9½ by 24 inches, and the effective table feed, 12 inches. There are twenty-four spindle speeds and twelve table feeds, ranging from 1 to 18 inches per minute.

**Machine Tool Motor Controller:** Cutler-Hammer Mfg. Co., Milwaukee, Wis. This controller, which is of the drum type, may be used with any class of motor-driven machine tool. A special resistance inserted in the shunt field circuit provides a speed regulation in a range of 3 to 1. The field regulating unit consists of a field-resistance commutator mounted on a drum shaft with the necessary resistances located underneath. The starting resistance on the armature circuit is mounted on a separate frame. The armature contact fingers and segments are of solid copper and are so arranged that dynamic braking is provided when the drum is returned to the "off" position.

**Lathe Attachment for Boring and Grinding Cylinders:** John Gibson Co., San Francisco, Cal. The attachment is intended principally for reboring and regrinding gas-engine cylinders, and the faceplate is arranged to take single or *en bloc* cylinder castings. The attachment is screwed to the lathe spindle and may be adjusted radially with reference to the axis of the lathe spindle. As a result, the abrasive wheel or cutting tool will travel in circles of varying diameters, corresponding to those of the cylinders being operated upon. The screw controlling this adjustment is graduated to 0.001 inch. This attachment is designed for use on lathes having a swing of 16 inches or more.

**Arc Welding System Using Constant Current:** Arc Welding Machine Co., Inc., New York City. This system consists of a generator to furnish the energy for welding, a regulator to maintain the current at constant value, and a motor for driving. By this arrangement, one size of wire may be used throughout the system, as the current is uniform and independent of the length of the circuit and the other operators. Switches are inserted in the line at the points where the welding is to be done and a special controller is plugged in across the switch. With this controller, it is possible to adjust the size of the arc to suit the work. When the welding operation is stopped, the arc is not broken, but is killed by placing a short-circuit across it.

* * *

To make your job "soft," put a lot of hard work into it.

## INDUSTRIAL ENGINEERING AND AMERICANIZATION

The immigration problem of the United States, while serious before the outbreak of the European war, is likely to be much more serious following its close. An investigation made under the direction of the transportation interests indicates that there will be a tremendous influx of foreign people who will seek a more favored land in order to escape ruinous taxation and the horrors of another possible conflict. The part played by the engineer in the problem of assimilating the immigrant and making him an American citizen was discussed at a dinner given Friday evening, January 19, by Mr. and Mrs. Astor at their residence in New York City. Dr. Ira N. Hollis, president of the American Society of Mechanical Engineers, dwelt on the moral equivalent of war and the part played by the immigrant in conquering the forces of nature and making them subservient to the will of man. Dr. Hollis expressed the belief that the engineer and the work of the engineer would eventually bring about lasting peace. His is a warfare for the benefit and not the destruction of mankind. Other speakers were Howard E. Coffin of the Council of National Defense, Gano Dunn, president of the J. G. White Engineering Co., Raymond B. Price of the U. S. Rubber Co., and George A. Cullen of the Delaware, Lackawanna & Western Railroad. Richard A. Feiss of the Joseph Feiss Co., Cleveland, Ohio, spoke on the importance of teaching the immigrant the English language and making it a condition of promotion that the employe be able to read and write English. Mr. Feiss and others expressed the belief that no other factor tends to make a foreigner an American in mind and heart as effectively as the ability to speak the language. If he speaks the language he becomes acquainted with Americans and learns to understand American institutions and customs.

The meeting was attended by about one hundred sixty engineers, professors of mechanical engineering, editors, and others interested in engineering in one phase or another. The object of the movement is "to include in industrial engineering the human factor in industrial organizations; to standardize welfare work in industry in point of view, principle and method; to extend scientific methods to the human phases of industrial organization and to train men to carry out these methods. The agents of industrial Americanization are held to be the engineers of America, in whose hands are the human as well as the mechanical destinies of industry."

* * *

## A SAD AWAKENING

The old saying, "Never too old to learn," is just as true today as ever. It has been particularly exemplified in the munition business in this country, and especially among the financiers in Wall St. The idea has prevailed in financial circles that money would do everything; for instance, that all it was necessary to do to manufacture a military rifle was to furnish the capital, and the rifles would be turned out automatically. That this is not the case has been forcibly pointed out of late by the failure of several munition manufacturers to make good.

Two years ago a large contract was placed in this country for 3,800,000 military rifles of a certain type. This contract was given to a financial concern who had enormous resources at its disposal. Contracts were immediately let for buildings of the very latest construction. The best machinery available in the country for this work was purchased and installed. Men were hired from the different arsenals throughout the country, and were put in charge of the various departments. These men had a wide experience in the production of military rifles. The fact was overlooked, however, that the production of a military rifle requires careful planning and a high order of executive ability. The men put in charge had not had experience with work done on so large a scale, and hence the planning—the most essential part—was completely ignored. Brick, mortar and machines were thought to be the chief requisites. Men with good mechanical experience and executive knowledge who did not appear to have the "pep" necessary

Fig. 1. New Machinery Warehouse built at Chicago, Ill., by Hill, Clarke & Co.

were quickly dispensed with and others possessing the faculty of "shooting the bluff" were placed in charge at fabulous salaries.

The financial world has had a sad awakening and one that it will remember for some time to come. It has learned that managing ability is of the greatest importance and should be considered first. It is to be regretted, however, that such a lesson was necessary before those possessed with large capital were able to see one of the fundamental issues in connection with the manufacture of any product, whether it be made on an interchangeable basis or not. D. T. H.

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## CHARLES H. BESLY & CO.'S FIRE

The offices and warehouse of Charles H. Besly & Co., 118-124 N. Clinton St., Chicago, were totally destroyed by fire Saturday morning, January 13. The building and contents were fully insured and the records found intact in the vaults. Edward P. Welles, the president, with his customary energy immediately arranged for temporary quarters, which were secured in the Ruprecht Building, on Randolph and Jefferson Sts. The Beloit factory is intact and running night and day, so there will be no trouble supplying the products manufactured there. Stocks of other tools and supplies of all kinds which C. H. Besly & Co. deal in are being rushed to Chicago, and with the kindly cooperation of other jobbers in that city and elsewhere the firm is already in a position to fill orders promptly.

The statements that the fire was of incendiary origin and that the company was manufacturing munitions are incorrect. Coming, as the fire did, immediately after the explosion of the DuPont Powder Works at Haskell, N. J., and the destruction of the Canadian Foundry & Machine Co.'s plant at Kingsland, N. J., many jumped to the conclusion that this also was an incendiary fire promoted by foreign interests. The company expects to rebuild on the old site immediately, and its architects are now preparing plans for a new building, which will be a model of its kind and embody many of Mr. Welles' up-to-date ideas in the construction of a warehouse and offices for the use of such a business.

## MACHINERY WAREHOUSE OF HILL, CLARKE & CO.

To provide for carrying a stock of machine tools, Hill, Clarke & Co. of Chicago, Ill., have constructed a warehouse at Chicago. This building is of brick, concrete and steel construction, and is provided with all the facilities for handling heavy machinery and "re-manufacturing" machine tools, a large part of the space in the new warehouse being given over to this work.

The building, which is 160 feet wide by 360 feet long, provides a floor space of about 55,000 square feet. From floor to roof, the height is 40 feet, and there is a maximum clearance of 25 feet under the crane hook. Two Pawling & Harnischfeger cranes are provided, each of which has a span of 75 feet; the building is divided into two longitudinal bays, and the cranes serve the entire floor space. The crane in the north bay has a capacity of 40 tons, while the crane in the south bay has a capacity of 10 tons. The building is heated by a battery of two seventy-five-horsepower Kewanee boilers. There is liberal window space all around the building, and there are eight skylights 65 feet long. Radiators run along the entire window

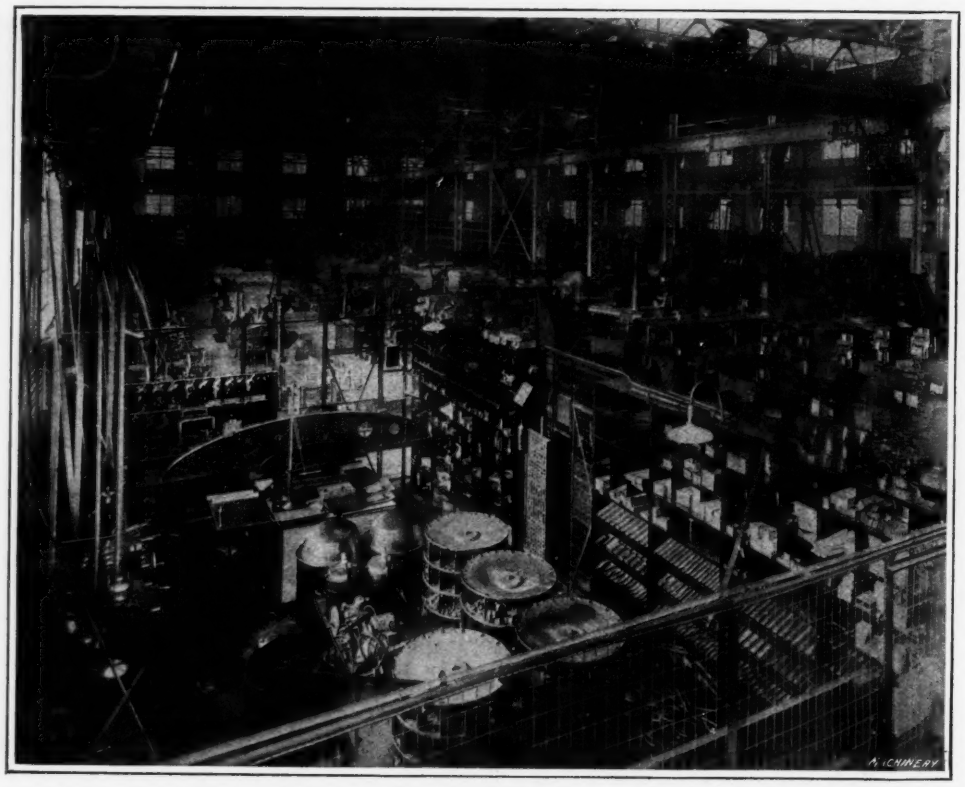

Fig. 2. View of Tool-room which is fully equipped with Tools and Supplies for re-manufacturing Machine Tools

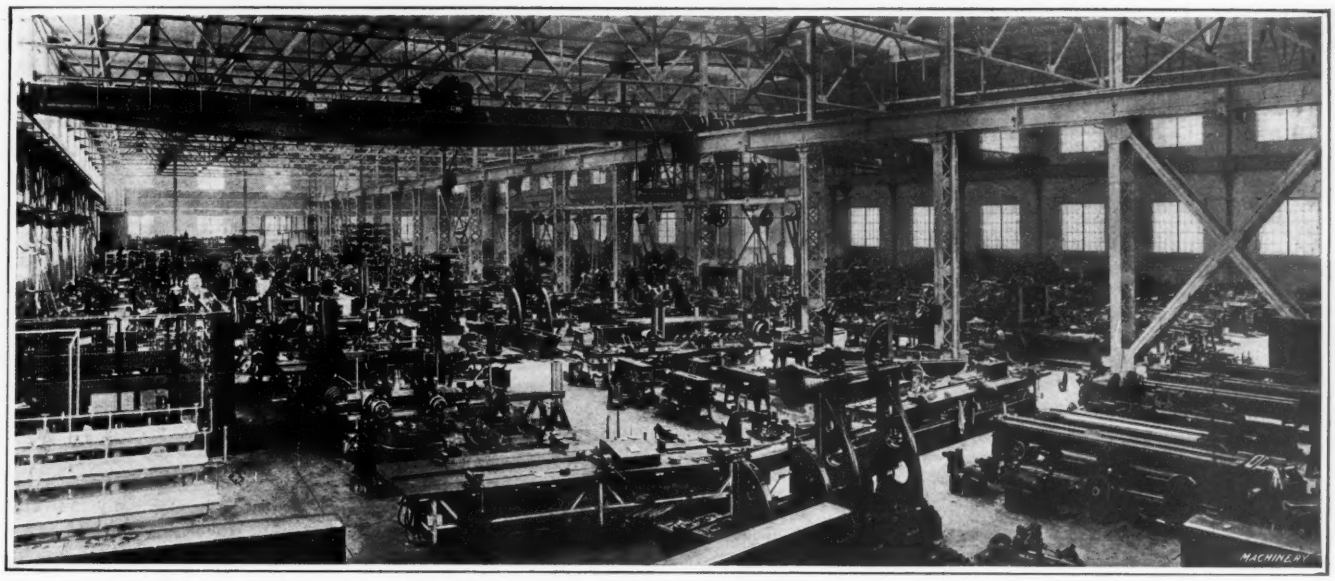

Fig. 3. Interior of Hill, Clarke & Co.'s Machinery Warehouse

space, and radiators are also furnished around each of the skylights. To insure efficient circulation of the steam, a vacuum pump is provided.

Two excellent features of the lay-out of this building are seen in the arrangement of window space and the design of the roof. It has already been stated that windows extend around the entire building, so that ample light is provided; these windows are placed at a height of about eight feet from the floor, so that the workman's attention is not distracted by occurrences outside. The roof slopes in toward the center, which directs the drainage to central pipes provided for carrying away the water. In winter this prevents the formation of icicles on the eaves.

Railroad shipping facilities are provided by a siding from the Chicago Belt Railroad, which makes connection with all lines coming into the city. In this way excellent shipping facilities are provided both to and from the warehouse. A track enters crosswise at the rear end of the building and runs the cars under one of the electric traveling cranes, making loading and unloading an easy matter. The doors at the front of the building are of sufficient height to clear any load that can be placed on horse-drawn or motor trucks by the electric cranes. The building is provided with a heavy concrete floor, which rests on a bed of cinders 18 inches in thickness. This floor is covered with a one-inch surface dressing, made of cement and granite screenings, instead of cement and sand, which does away with all tendency of the floor to "dust," not only making the building more sanitary, but also preventing fine grit from finding its way into machine bearings and causing damage.

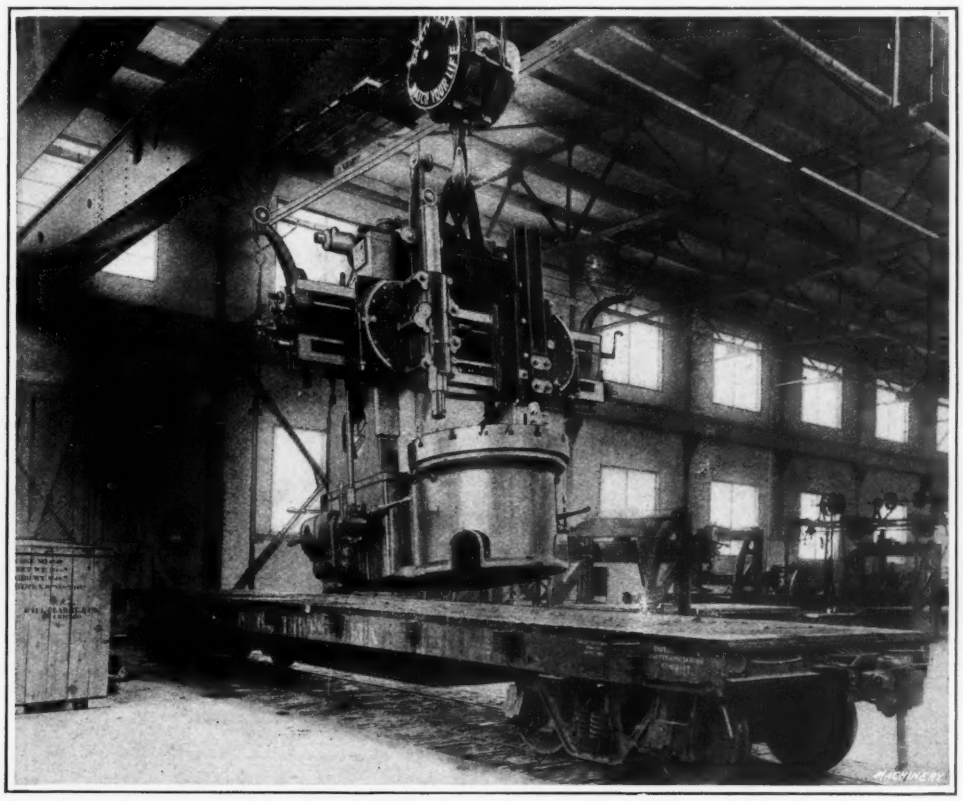

Fig. 4. Lifting a Heavy Machine from a Car with a Pawling & Harnischfeger Electric Crane

### Re-manufacturing Machine Tools

For several years Hill, Clarke & Co. of Chicago have been doing an extensive business in second-hand machinery, and have developed the process of rebuilding to a high plane. Each machine that comes into the shop is completely disassembled and all parts are carefully examined to ascertain any possible damage they may have received while in use. This practice is followed even in the case of machines which are practically new, the routine through which all machines are put consisting of first thoroughly cleaning all parts and testing all flat surfaces with straightedges or surface plates. The flat surfaces are then hand-scraped to B. & S. surface plates, and if badly worn they are planed before being scraped. All cylindrical bearings are re-aligned, and such bearings are renewed when necessary. Any damaged parts are repaired or replaced, the idea in all cases being to make them as good as new.

All enamel and filler is scraped off the castings, which are then refilled and re-enameled, and all bright parts are polished, which, in connection with the refinished castings, gives the machine the appearance of being new. All adjustments are made under the supervision of four competent foremen, who carry out instructions given by a superintendent who has had wide experience in machine tool building. Finally, each machine is tested under belt to determine its ability to give satisfactory results, both as regards smoothness of operation and accuracy of work produced. To the reader who is familiar with average practice in rebuilding second-hand machinery for the market, it will be apparent that the practice of Hill, Clarke & Co. is carried much further than that of the average

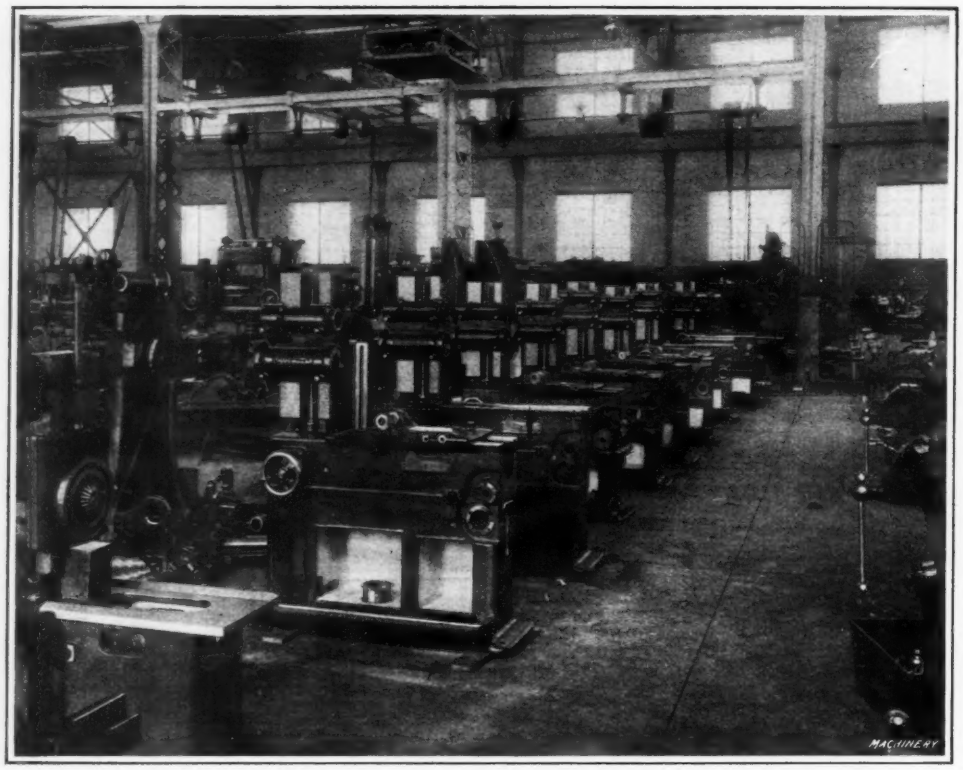

Fig. 5. Line of Brown & Sharpe No. 13 Gear-cutting Machines in Process of re-manufacturing

dealer in so-called rebuilt machine tools. It was on this account that the present firm adopted the term "re-manufactured" machine tools to designate its product. All machinery of this class is sold under the following guarantee: "If a machine is not suited for your work, if it disappoints you in any way, send it back within thirty days from date of shipment, freight prepaid, and we will cheerfully refund your purchase price in full." This guarantee, coupled with the favorable impression gained from an inspection of the way in which work is carried out in the shop, has led many firms that have never before placed any second-hand tools in their shops to purchase re-manufactured machinery.

* * *

## PUBLIC OWNERSHIP DOES NOT PAY?

The opponents of municipal and government ownership of public utilities claim that public ownership never pays a profit. Of course it does not; in fact, no human activity pays a profit in the last analysis, as can be easily shown. Let the advocates of private ownership analyze the economics of existence. Let them look back through history and determine what has been the inheritance of mankind. They will find that the only human things that endure are the race and a portion of its accumulated knowledge. Mankind bridges time by the succession of generations; but practically all its works eventually disappear. It makes little difference whether they are perishable products or engineering structures; they are all consumed or wasted away by the tooth of time. We are the inheritors of the past in name more than in fact; food, clothing, dwellings, factories, roads, railways, machinery, shipping and every form of wealth are constantly being used up and must constantly be renewed.

The companies enjoying the private ownership of public utilities are free to pick and choose the best labor, and leave the common, inefficient labor to shift for itself. Their rates are fixed at a liberal margin above cost, and as a result they are generally able to operate their utilities at a profit. But a publicly owned utility, if it is of broad extent, must necessarily employ that portion of the community that is representative of the average. If all utilities were publicly owned, it is quite evident that no profit from their operation could result. No government makes a profit; it is impossible. Profit means something accumulated at the expense of the customers. If everyone is customer and owner at once, there can be no such thing as profit or loss, except that in the last analysis everything is consumed.

All publicly owned utilities must necessarily be at a disadvantage when compared with private utilities. The private utility is able to hire a high-priced man to act as manager who may be of unusual ability. His talents are directed to saddling losses on others and profits on his own concern. If the able manager had to work for all the owners of the community, his fine showing would disappear.

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## ENGLISH AND METRIC DRILL SIZES

With the growth of the nation's export trade, there has come an increasing demand that the metric system of measurements be used in the manufacture of American machinery. Although it is improbable that this system will displace the English system of measurements in this country, shops that have an export trade must be familiar with both. For that reason we give here the English and metric twist drill sizes and the equivalent decimal parts of an inch. Millimeter drills can often be used in manufacturing where close limits are desired, and as they can be purchased in the open market, the expense of making special reamers will be avoided. H. J.

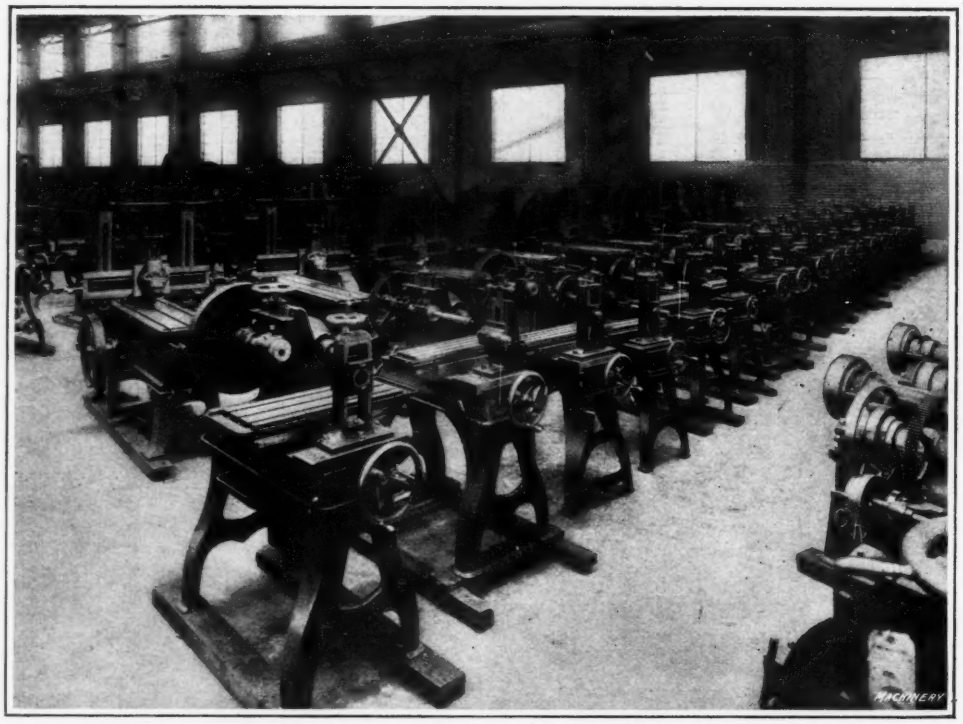


Fig. 6. Re-manufactured Planers and Lincoln Milling Machines Complete and Ready for Sale

## ENGLISH AND METRIC TWIST DRILL SIZES

| No. or Letter of Drill | Diameter, Inch | Diameter, Millimeters | Decimal Equivalent of Inch | No. or Letter of Drill | Diameter, Inch | Diameter, Millimeters | Decimal Equivalent of Inch | No. or Letter of Drill | Diameter, Inch | Diameter, Millimeters | Decimal Equivalent of Inch |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 80 | | | 0.0135 | | | 3.2 | 0.1259 | | | 7.0 | 0.2756 |
| 79 | | | 0.0145 | 30 | | | 0.1285 | J | | | 0.2770 |
| | 1/64 | | 0.0156 | | | 3.3 | 0.1299 | | | 7.1 | 0.2795 |
| | | 0.4 | 0.0157 | | | 3.4 | 0.1339 | K | | | 0.2810 |
| 78 | | | 0.0160 | 29 | | | 0.1360 | | 9/32 | | 0.2812 |
| 77 | | | 0.0180 | | | 3.5 | 0.1378 | | | 7.2 | 0.2835 |
| | | 0.5 | 0.0197 | 28 | | | 0.1405 | | | 7.3 | 0.2874 |
| 76 | | | 0.0200 | | 9/64 | | 0.1406 | L | | | 0.2900 |
| 75 | | | 0.0210 | | | 3.6 | 0.1417 | | | 7.4 | 0.2913 |
| 74 | | | 0.0225 | 27 | | | 0.1440 | M | | | 0.2950 |
| | | 0.6 | 0.0236 | | | 3.7 | 0.1457 | | | 7.5 | 0.2953 |
| 73 | | | 0.0240 | 26 | | | 0.1470 | | 19/64 | | 0.2968 |
| 72 | | | 0.0250 | 25 | | | 0.1495 | | | 7.6 | 0.2992 |
| 71 | | | 0.0260 | | | 3.8 | 0.1496 | N | | | 0.3020 |
| | | 0.7 | 0.0276 | 24 | | | 0.1520 | | | 7.7 | 0.3031 |
| 70 | | | 0.0280 | | | 3.9 | 0.1535 | | | 7.8 | 0.3071 |
| 69 | | | 0.0292 | 23 | | | 0.1540 | | | 7.9 | 0.3110 |
| 68 | | | 0.0310 | | 5/32 | | 0.1562 | | 5/16 | | 0.3125 |
| | 1/32 | | 0.0312 | 22 | | | 0.1570 | | | 8.0 | 0.3149 |
| | | 0.8 | 0.0315 | | | 4.0 | 0.1575 | O | | | 0.3160 |
| 67 | | | 0.0320 | 21 | | | 0.1590 | | | 8.1 | 0.3189 |
| 66 | | | 0.0330 | 20 | | | 0.1610 | | | 8.2 | 0.3228 |
| 65 | | | 0.0350 | | | 4.1 | 0.1614 | P | | | 0.3230 |
| | | 0.9 | 0.0354 | | | 4.2 | 0.1654 | | | 8.3 | 0.3268 |
| 64 | | | 0.0360 | 19 | | | 0.1660 | | 21/64 | | 0.3281 |
| 63 | | | 0.0370 | | | 4.3 | 0.1693 | | | 8.4 | 0.3307 |
| 62 | | | 0.0380 | 18 | | | 0.1695 | Q | | | 0.3320 |
| 61 | | | 0.0390 | | 11/64 | | 0.1718 | | | 8.5 | 0.3347 |
| | | 1.0 | 0.0394 | 17 | | | 0.1730 | | | 8.6 | 0.3386 |
| 60 | | | 0.0400 | | | 4.4 | 0.1732 | R | | | 0.3390 |
| 59 | | | 0.0410 | 16 | | | 0.1770 | | | 8.7 | 0.3425 |
| 58 | | | 0.0420 | | | 4.5 | 0.1772 | | 11/32 | | 0.3437 |
| 57 | | | 0.0430 | 15 | | | 0.1800 | | | 8.8 | 0.3465 |
| | | 1.1 | 0.0433 | | | 4.6 | 0.1811 | S | | | 0.3480 |
| 56 | | | 0.0465 | 14 | | | 0.1820 | | | 8.9 | 0.3504 |
| | 3/64 | | 0.0468 | 13 | | | 0.1850 | | | 9.0 | 0.3543 |
| | | 1.2 | 0.0472 | | | 4.7 | 0.1850 | T | | | 0.3580 |
| | | 1.3 | 0.0512 | | 3/16 | | 0.1875 | | | 9.1 | 0.3583 |
| 55 | | | 0.0520 | | | 4.8 | 0.1889 | | 23/64 | | 0.3593 |
| 54 | | | 0.0550 | 12 | | | 0.1890 | | | 9.2 | 0.3622 |
| | | 1.4 | 0.0551 | 11 | | | 0.1910 | | | 9.3 | 0.3661 |
| | | 1.5 | 0.0591 | | | 4.9 | 0.1929 | U | | | 0.3680 |
| 53 | | | 0.0595 | 10 | | | 0.1935 | | | 9.4 | 0.3701 |
| | 1/16 | | 0.0625 | 9 | | | 0.1960 | | | 9.5 | 0.3740 |
| | | 1.6 | 0.0630 | | | 5.0 | 0.1969 | | 3/8 | | 0.3750 |
| 52 | | | 0.0635 | 8 | | | 0.1990 | V | | | 0.3770 |
| | | 1.7 | 0.0669 | | | 5.1 | 0.2008 | | | 9.6 | 0.3779 |
| 51 | | | 0.0670 | 7 | | | 0.2010 | | | 9.7 | 0.3819 |
| 50 | | | 0.0700 | | 13/64 | | 0.2031 | | | 9.8 | 0.3858 |
| | | 1.8 | 0.0709 | 6 | | | 0.2040 | W | | | 0.3860 |
| 49 | | | 0.0730 | | | 5.2 | 0.2047 | | | 9.9 | 0.3898 |
| | | 1.9 | 0.0748 | 5 | | | 0.2055 | | 25/64 | | 0.3906 |
| 48 | | | 0.0760 | | | 5.3 | 0.2087 | | | 10.0 | 0.3937 |
| | 5/64 | | 0.0781 | 4 | | | 0.2090 | X | | | 0.3970 |
| 47 | | | 0.0785 | | | 5.4 | 0.2126 | Y | | | 0.4040 |
| | | 2.0 | 0.0787 | 3 | | | 0.2130 | | 13/32 | | 0.4062 |
| 46 | | | 0.0810 | | | 5.5 | 0.2165 | Z | | | 0.4130 |
| 45 | | | 0.0820 | | 7/32 | | 0.2187 | | | 10.5 | 0.4134 |
| | | 2.1 | 0.0827 | | | 5.6 | 0.2205 | | 27/64 | | 0.4218 |
| 44 | | | 0.0860 | 2 | | | 0.2210 | | | 11.0 | 0.4330 |
| | | 2.2 | 0.0866 | | | 5.7 | 0.2244 | | 7/16 | | 0.4375 |
| 43 | | | 0.0890 | 1 | | | 0.2280 | | | 11.5 | 0.4520 |
| | | 2.3 | 0.0906 | | | 5.8 | 0.2284 | | 29/64 | | 0.4531 |
| 42 | | | 0.0935 | | | 5.9 | 0.2323 | | 15/32 | | 0.4687 |
| | 3/32 | | 0.0937 | A | | | 0.2340 | | | 12.0 | 0.4724 |
| | | 2.4 | 0.0945 | | 15/64 | | 0.2343 | | 31/64 | | 0.4843 |
| 41 | | | 0.0960 | | | 6.0 | 0.2362 | | | 12.5 | 0.4921 |
| 40 | | | 0.0980 | B | | | 0.2380 | | 1/2 | | 0.5000 |
| | | 2.5 | 0.0984 | | | 6.1 | 0.2402 | | | 13.0 | 0.5118 |
| 39 | | | 0.0995 | C | | | 0.2420 | | 33/64 | | 0.5156 |
| 38 | | | 0.1015 | | | 6.2 | 0.2441 | | 17/32 | | 0.5312 |
| | | 2.6 | 0.1024 | D | | | 0.2460 | | | 13.5 | 0.5315 |
| 37 | | | 0.1040 | | | 6.3 | 0.2480 | | 35/64 | | 0.5468 |
| | | 2.7 | 0.1063 | E | | | 0.2500 | | | 14.0 | 0.5512 |
| 36 | | | 0.1065 | | 1/4 | | 0.2500 | | 9/16 | | 0.5625 |
| | 7/64 | | 0.1095 | | | 6.4 | 0.2519 | | | 14.5 | 0.5709 |
| 35 | | | 0.1100 | | | 6.5 | 0.2559 | | 37/64 | | 0.5781 |
| | | 2.8 | 0.1102 | F | | | 0.2570 | | | 15.0 | 0.5905 |
| 34 | | | 0.1110 | | | 6.6 | 0.2598 | | 19/32 | | 0.5937 |
| 33 | | | 0.1130 | G | | | 0.2610 | | 39/64 | | 0.6093 |
| | | 2.9 | 0.1142 | | | 6.7 | 0.2638 | | | 15.5 | 0.6102 |
| 32 | | | 0.1160 | | 17/64 | | 0.2656 | | 5/8 | | 0.6250 |
| | | 3.0 | 0.1181 | H | | | 0.2660 | | | 16.0 | 0.6299 |
| 31 | | | 0.1200 | | | 6.8 | 0.2677 | | 41/64 | | 0.6406 |
| | | 3.1 | 0.1221 | | | 6.9 | 0.2716 | | | 16.5 | 0.6496 |
| | 1/8 | | 0.1250 | I | | | 0.2720 | | 21/32 | | 0.6562 |

*Machinery*

## ENGLISH AND METRIC TWIST DRILL SIZES

| No. or Letter of Drill | Diameter, Inch | Diameter, Millimeters | Decimal Equivalent of Inch |
|---|---|---|---|
| | | 17.0 | 0.6693 |
| | 43/64 | | 0.6718 |
| | 11/16 | | 0.6875 |
| | | 17.5 | 0.6890 |
| | 45/64 | | 0.7031 |
| | | 18.0 | 0.7087 |
| | 23/32 | | 0.7187 |
| | | 18.5 | 0.7283 |
| | 47/64 | | 0.7343 |
| | | 19.0 | 0.7480 |
| | 3/4 | | 0.7500 |
| | 49/64 | | 0.7656 |
| | | 19.5 | 0.7677 |
| | 25/32 | | 0.7812 |
| | | 20.0 | 0.7874 |
| | 51/64 | | 0.7968 |
| | | 20.5 | 0.8071 |
| | 13/16 | | 0.8125 |
| | | 21.0 | 0.8268 |
| | 53/64 | | 0.8281 |
| | 27/32 | | 0.8437 |
| | | 21.5 | 0.8465 |
| | 55/64 | | 0.8593 |
| | | 22.0 | 0.8661 |
| | 7/8 | | 0.8750 |
| | | 22.5 | 0.8858 |
| | 57/64 | | 0.8906 |
| | | 23.0 | 0.9055 |
| | 29/32 | | 0.9062 |
| | 59/64 | | 0.9218 |
| | | 23.5 | 0.9252 |
| | 15/16 | | 0.9375 |
| | | 24.0 | 0.9449 |
| | 61/64 | | 0.9531 |
| | | 24.5 | 0.9646 |
| | 31/32 | | 0.9687 |
| | | 25.0 | 0.9842 |
| | 63/64 | | 0.9843 |
| | 1 | | 1.0000 |
| | | 25.5 | 1.0039 |
| | 1 1/64 | | 1.0156 |
| | | 26.0 | 1.0236 |
| | 1 1/32 | | 1.0312 |
| | | 26.5 | 1.0433 |
| | 1 3/64 | | 1.0468 |
| | 1 1/16 | | 1.0625 |
| | | 27.0 | 1.0630 |
| | 1 5/64 | | 1.0781 |
| | | 27.5 | 1.0827 |
| | 1 3/32 | | 1.0937 |
| | | 28.0 | 1.1024 |
| | 1 7/64 | | 1.1093 |
| | | 28.5 | 1.1220 |
| | 1 1/8 | | 1.1250 |
| | 1 9/64 | | 1.1406 |
| | | 29.0 | 1.1417 |
| | 1 5/32 | | 1.1562 |
| | | 29.5 | 1.1614 |
| | 1 11/64 | | 1.1718 |
| | | 30.0 | 1.1811 |
| | 1 3/16 | | 1.1875 |
| | | 30.5 | 1.2008 |
| | 1 13/64 | | 1.2031 |
| | 1 7/32 | | 1.2187 |
| | | 31.0 | 1.2205 |
| | 1 15/64 | | 1.2343 |
| | | 31.5 | 1.2402 |
| | 1 1/4 | | 1.2500 |
| | | 32.0 | 1.2598 |
| | 1 17/64 | | 1.2656 |
| | | 32.5 | 1.2795 |
| | 1 9/32 | | 1.2812 |
| | 1 19/64 | | 1.2968 |
| | | 33.0 | 1.2992 |
| | 1 5/16 | | 1.3125 |
| | | 33.5 | 1.3189 |
| | 1 21/64 | | 1.3281 |
| | | 34.0 | 1.3386 |
| | 1 11/32 | | 1.3437 |
| | | 34.5 | 1.3583 |
| | 1 23/64 | | 1.3593 |
| | 1 3/8 | | 1.3750 |
| | | 35.0 | 1.3779 |
| | 1 25/64 | | 1.3906 |
| | | 35.5 | 1.3976 |
| | 1 13/32 | | 1.4062 |
| | | 36.0 | 1.4173 |
| | 1 27/64 | | 1.4218 |
| | | 36.5 | 1.4370 |
| | 1 7/16 | | 1.4375 |
| | 1 29/64 | | 1.4531 |
| | | 37.0 | 1.4567 |
| | 1 15/32 | | 1.4687 |
| | | 37.5 | 1.4764 |
| | 1 31/64 | | 1.4843 |
| | | 38.0 | 1.4961 |
| | 1 1/2 | | 1.5000 |
| | 1 33/64 | | 1.5156 |
| | | 38.5 | 1.5157 |
| | 1 17/32 | | 1.5312 |
| | | 39.0 | 1.5354 |
| | 1 35/64 | | 1.5468 |
| | | 39.5 | 1.5551 |
| | 1 9/16 | | 1.5625 |
| | | 40.0 | 1.5748 |
| | 1 37/64 | | 1.5781 |
| | 1 19/32 | | 1.5937 |
| | | 40.5 | 1.5945 |
| | 1 39/64 | | 1.6093 |
| | | 41.0 | 1.6142 |
| | 1 5/8 | | 1.6250 |
| | | 41.5 | 1.6339 |
| | 1 41/64 | | 1.6406 |
| | | 42.0 | 1.6535 |
| | 1 21/32 | | 1.6562 |
| | 1 43/64 | | 1.6718 |
| | | 42.5 | 1.6732 |
| | 1 11/16 | | 1.6875 |
| | | 43.0 | 1.6929 |
| | 1 45/64 | | 1.7031 |
| | | 43.5 | 1.7126 |
| | 1 23/32 | | 1.7187 |
| | | 44.0 | 1.7323 |
| | 1 47/64 | | 1.7343 |
| | 1 3/4 | | 1.7500 |
| | | 44.5 | 1.7520 |
| | 1 49/64 | | 1.7656 |
| | | 45.0 | 1.7716 |
| | 1 25/32 | | 1.7812 |
| | | 45.5 | 1.7913 |
| | 1 51/64 | | 1.7968 |
| | | 46.0 | 1.8110 |
| | 1 13/16 | | 1.8125 |
| | 1 53/64 | | 1.8281 |
| | | 46.5 | 1.8307 |
| | 1 27/32 | | 1.8437 |
| | | 47.0 | 1.8504 |
| | 1 55/64 | | 1.8593 |
| | | 47.5 | 1.8701 |
| | 1 7/8 | | 1.8750 |
| | | 48.0 | 1.8898 |
| | 1 57/64 | | 1.8906 |
| | 1 29/32 | | 1.9062 |
| | | 48.5 | 1.9094 |
| | 1 59/64 | | 1.9218 |
| | | 49.0 | 1.9291 |
| | 1 15/16 | | 1.9375 |
| | | 49.5 | 1.9488 |
| | 1 61/64 | | 1.9531 |
| | | 50.0 | 1.9685 |
| | 1 31/32 | | 1.9687 |
| | 1 63/64 | | 1.9843 |
| | | 50.5 | 1.9882 |
| | 2 | | 2.0000 |

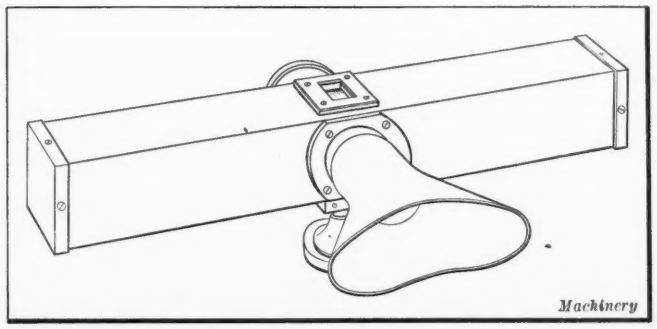
*Machinery*

## WEDGE OPTICAL PYROMETER

To meet the demand for a simple form of pyrometer suitable for use by the average shop man, Barnes & Morris, 182 and 183 Temple Chambers, London, England, have recently placed on the market an instrument known as the Wedge optical pyrometer. It is stated that this is a perfectly reliable instrument, and that after half an hour's practice, any intelligent man can estimate temperature with a limit of accuracy of 18 degrees or even 9 degrees F. in exceptional cases. This instrument can be employed wherever the heated body is visible, either directly or by reflection. Its range is from any temperature at which the object becomes visibly red, say 932 degrees F., up to the highest temperatures.

The pyrometer consists of a brass tube furnished with a small telescope arranged in such a way that the objective of the telescope focuses the image of the heated object on a movable prism placed inside the tube. The eye-piece of the pyrometer telescope then reveals the magnified image on the prism. A suitable shield is provided to prevent exterior light from reaching the eye, and at one side of the pyrometer tube there is a knurled head which actuates a rack and pinion that moves the prism through the field of vision. This prism is made of specially prepared dark glass, so that it cuts off the light emitted by the heated body at various temperatures. For example, in looking at a heated bar of steel, suppose the temperature is 1832 degrees F.; upon turning the screw, the thicker part of the prism comes gradually into the field of vision and the image gradually appears to become darker and darker in color until at a given point the color entirely disappears. This point is marked by an indicator on top of the pyrometer tube, which consists of a scale that moves under a line on the glass window through which this scale is viewed. Reference to the scale enables the temperature of the heated object to be read. Naturally, a little practice is required to decide the exact moment when the color disappears, and it is on this account that a certain amount of experience is necessary in order to obtain accurate results with a Wedge pyrometer.

In the case of increasing temperatures the method of procedure is to watch the object through the telescope and gradually turn the milled head until the color is obliterated. The scale reading indicates the actual temperature of the heated object, and the distance of the object from the observer makes no difference to the reading, provided the heated surface is visible. In cases where layers of carbonic oxide, carbonic acid gas or steam intervene between the instrument and the heated object, the reading of temperature obtained will be slightly lower than the actual figure. For this reason, when observing the temperature of melted metal in a crucible, it is a good plan to plunge a tube a few inches below the surface of the metal, making the observation directly down the tube. In this way the surface is protected from fumes and greater accuracy is likely to result. Advantages claimed by the Wedge optical




Wedge Optical Pyrometer in which Measurement of Temperature is dependent upon Intensity of Light emitted from Heated Body

pyrometer are its simple construction and the ease with which it may be operated, the fact that it is self-contained and does not require the use of any accessories, elimination of danger of breaking the instrument—which is an important feature when compared with the more complicated instruments that are only suitable for use by scientific men—and, finally, the fact that this instrument enables accurate temperature regulation to be provided in many instances where it is not deemed advisable to install more complicated forms of temperature measuring apparatus. The instrument is calibrated to cover any range of temperatures desired between the limits of 500 degrees C. (932 degrees F.) and 2100 degrees C. (3812 degrees F.); generally speaking, a single instrument is arranged to cover a range of 400 degrees C. (720 degrees F.), the scale being divided into intervals of 20 degrees C. (36 degrees F.).

* * *

## PUNCH GRINDING MACHINE

The grinding machine here described, which is in use at the factory of the Willemin Mfg. Co., Inc., Providence, R. I.,

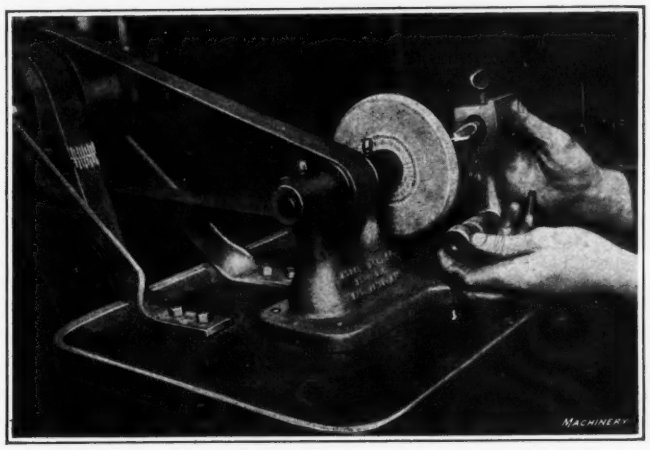



Fig. 1. Punch Grinding Machine in Operation, showing Micrometer Adjustment

is noticeable for its simplicity, yet it accomplishes certain results more satisfactorily than some larger and more expensive machines. At right angles to the center line of the emery wheel spindle is mounted the work-holding arm. There is a large hole at the working end of this arm, the lower portion of which is shaped to a V. This facilitates holding circular work, which is largely what a machine of this type is called upon to handle. The other end of the work-holding arm is constructed to slide or clamp around a rod which is parallel to the center line of the emery wheel spindle. This arm also swings radially around the rod mentioned, and in this way the work is brought into contact with the emery wheel. For large adjustments, such as two or three inches, the work arm is unclamped from the spindle on which it slides, and moved to the desired position. For minute adjustments up to one inch, the entire rod may be moved to or from the emery wheel by the knurled finger nut shown. This machine has been found useful for sharpening punches with a circular shank. There are numerous other uses to which it can be put, but it was found especially effective for squaring off a large number of small circular pieces

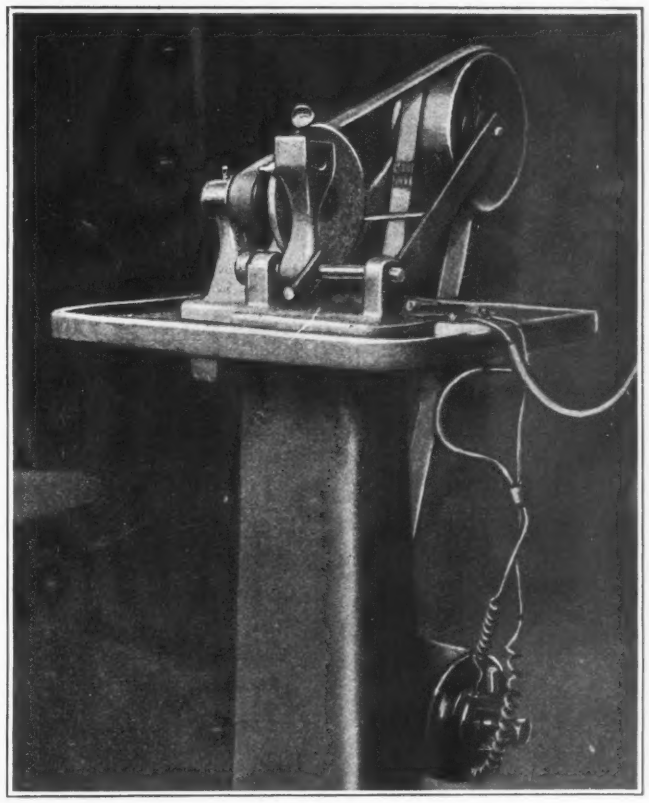


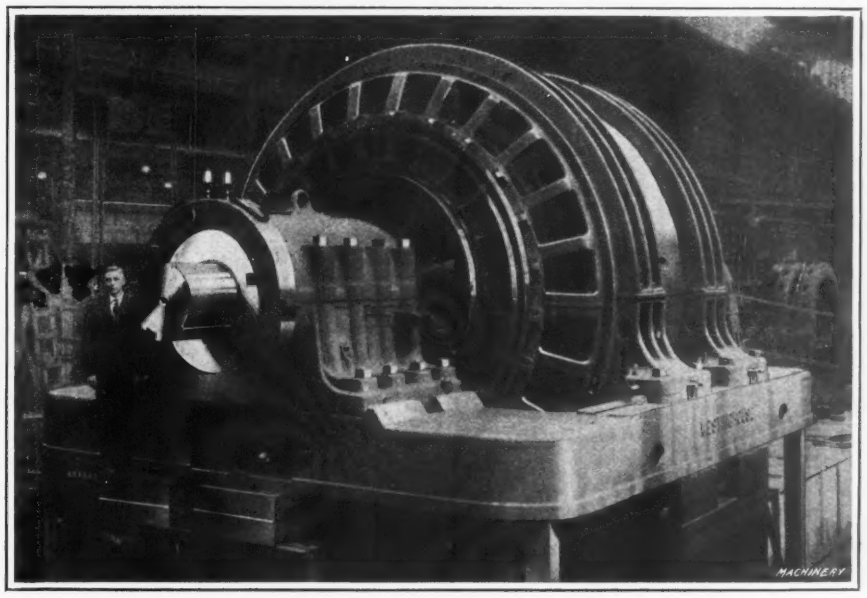
Fig. 2. View of Punch Grinding Machine showing Motor Drive

which had been cut off in a screw machine. On work of this kind it is a simple operation to slip one of the pieces into the work arm and pass it across the emery wheel face. V. B.

* * *

## HUGE REVERSING MOTOR

The illustration shows what is said to be the largest electric motor in the world. It was built by the Westinghouse Electric & Mfg. Co. for driving a 35-inch, two-high reversing blooming mill in a steel plant, and is rated at 15,000 horsepower. An idea of the size of this gigantic motor is gained from the figure of the man standing beside the bearing, who is 6 feet tall. Reversals can be made in two seconds from full speed ahead to full speed reverse. The complete motor weighs 250 tons, the rotor alone weighing about 100 tons. It stands twenty feet high and the shaft is two feet in diameter.




Westinghouse 15,000-horsepower Reversing Motor for Blooming Mill

## AREAS OF CIRCLES IN SQUARE INCHES, WHEN DIAMETERS ARE GIVEN IN MILLIMETERS

| Diameter Millimeters | Area, Square Inches | Diameter, Millimeters | Area, Square Inches | Diameter, Millimeters | Area, Square Inches | Diameter, Millimeters | Area, Square Inches | Diameter, Millimeters | Area, Square Inches | Diameter, Millimeters | Area, Square Inches |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.001217 | 86 | 9.00366 | 171 | 35.59711 | 256 | 79.78156 | 341 | 141.55700 | 426 | 220.92343 |
| 2 | 0.004869 | 87 | 9.21427 | 172 | 36.01467 | 257 | 80.40607 | 342 | 142.38846 | 427 | 221.96185 |
| 3 | 0.010956 | 88 | 9.42731 | 173 | 36.43466 | 258 | 81.03301 | 343 | 143.22236 | 428 | 223.00270 |
| 4 | 0.019477 | 89 | 9.64278 | 174 | 36.85709 | 259 | 81.66239 | 344 | 144.05869 | 429 | 224.04599 |
| 5 | 0.030434 | 90 | 9.86069 | 175 | 37.28195 | 260 | 82.29421 | 345 | 144.89746 | 430 | 225.09171 |
| 6 | 0.043825 | 91 | 10.08104 | 176 | 37.70925 | 261 | 82.92846 | 346 | 145.73866 | 431 | 226.13986 |
| 7 | 0.059651 | 92 | 10.30381 | 177 | 38.13898 | 262 | 83.56514 | 347 | 146.58230 | 432 | 227.19045 |
| 8 | 0.077911 | 93 | 10.52903 | 178 | 38.57115 | 263 | 84.20426 | 348 | 147.58237 | 433 | 228.24348 |
| 9 | 0.098606 | 94 | 10.75668 | 179 | 39.00575 | 264 | 84.84581 | 349 | 148.27688 | 434 | 229.29894 |
| 10 | 0.121737 | 95 | 10.98676 | 180 | 39.44278 | 265 | 85.48980 | 350 | 149.12782 | 435 | 230.35683 |
| 11 | 0.147301 | 96 | 11.21928 | 181 | 39.88225 | 266 | 86.13623 | 351 | 149.98120 | 436 | 231.41716 |
| 12 | 0.175301 | 97 | 11.45423 | 182 | 40.32416 | 267 | 86.78508 | 352 | 150.83701 | 437 | 232.47993 |
| 13 | 0.205735 | 98 | 11.69162 | 183 | 40.76850 | 268 | 87.43638 | 353 | 151.69525 | 438 | 233.54513 |
| 14 | 0.238604 | 99 | 11.93144 | 184 | 41.21527 | 269 | 88.09011 | 354 | 152.55593 | 439 | 234.61276 |
| 15 | 0.273908 | 100 | 12.17370 | 185 | 41.66448 | 270 | 88.74627 | 355 | 153.41905 | 440 | 235.68283 |
| 16 | 0.311646 | 101 | 12.41839 | 186 | 42.11613 | 271 | 89.40487 | 356 | 154.28460 | 441 | 236.75533 |
| 17 | 0.351819 | 102 | 12.66551 | 187 | 42.57021 | 272 | 90.06590 | 357 | 155.15258 | 442 | 237.83027 |
| 18 | 0.394427 | 103 | 12.91507 | 188 | 43.02672 | 273 | 90.72936 | 358 | 156.02300 | 443 | 238.90764 |
| 19 | 0.439470 | 104 | 13.16707 | 189 | 43.48567 | 274 | 91.39527 | 359 | 156.89586 | 444 | 239.98745 |
| 20 | 0.486948 | 105 | 13.42150 | 190 | 43.94705 | 275 | 92.06360 | 360 | 157.77115 | 445 | 241.06969 |
| 21 | 0.536860 | 106 | 13.67836 | 191 | 44.41087 | 276 | 92.73437 | 361 | 158.64887 | 446 | 242.15437 |
| 22 | 0.589207 | 107 | 13.93766 | 192 | 44.87712 | 277 | 93.40758 | 362 | 159.52903 | 447 | 243.24148 |
| 23 | 0.643988 | 108 | 14.19940 | 193 | 45.34581 | 278 | 94.08322 | 363 | 160.41162 | 448 | 244.33102 |
| 24 | 0.701205 | 109 | 14.46357 | 194 | 45.81691 | 279 | 94.76129 | 364 | 161.29665 | 449 | 245.42300 |
| 25 | 0.760856 | 110 | 14.73017 | 195 | 46.29049 | 280 | 95.44180 | 365 | 162.18411 | 450 | 246.51742 |
| 26 | 0.822942 | 111 | 14.99921 | 196 | 46.76648 | 281 | 96.24752 | 366 | 163.07401 | 451 | 247.61427 |
| 27 | 0.887462 | 112 | 15.27068 | 197 | 47.24491 | 282 | 96.81013 | 367 | 163.96634 | 452 | 248.71356 |
| 28 | 0.954418 | 113 | 15.54459 | 198 | 47.72577 | 283 | 97.49794 | 368 | 164.86111 | 453 | 249.81528 |
| 29 | 1.02380 | 114 | 15.82094 | 199 | 48.20906 | 284 | 98.18819 | 369 | 165.75831 | 454 | 250.91943 |
| 30 | 1.09563 | 115 | 16.09971 | 200 | 48.69480 | 285 | 98.88087 | 370 | 166.65795 | 455 | 252.02602 |
| 31 | 1.16989 | 116 | 16.38093 | 201 | 49.18296 | 286 | 99.57599 | 371 | 167.56002 | 456 | 253.13504 |
| 32 | 1.24658 | 117 | 16.66457 | 202 | 49.67356 | 287 | 100.27354 | 372 | 168.46453 | 457 | 254.24650 |
| 33 | 1.32571 | 118 | 16.95065 | 203 | 50.16660 | 288 | 100.97353 | 373 | 169.37147 | 458 | 255.36040 |
| 34 | 1.40727 | 119 | 17.23917 | 204 | 50.66206 | 289 | 101.67595 | 374 | 170.28084 | 459 | 256.47672 |
| 35 | 1.49127 | 120 | 17.53012 | 205 | 51.15997 | 290 | 102.38081 | 375 | 171.19265 | 460 | 257.59549 |
| 36 | 1.57771 | 121 | 17.82351 | 206 | 51.66031 | 291 | 103.08810 | 376 | 172.10690 | 461 | 258.71668 |
| 37 | 1.66658 | 122 | 18.11933 | 207 | 52.16308 | 292 | 103.79783 | 377 | 173.02358 | 462 | 259.84032 |
| 38 | 1.75788 | 123 | 18.41759 | 208 | 52.66829 | 293 | 104.50999 | 378 | 173.94269 | 463 | 260.96638 |
| 39 | 1.85161 | 124 | 18.71828 | 209 | 53.17593 | 294 | 105.22459 | 379 | 174.86424 | 464 | 262.09489 |
| 40 | 1.94779 | 125 | 19.02140 | 210 | 53.68601 | 295 | 105.94162 | 380 | 175.78822 | 465 | 263.22582 |
| 41 | 2.04639 | 126 | 19.32696 | 211 | 54.19852 | 296 | 106.66108 | 381 | 176.71464 | 466 | 264.35919 |
| 42 | 2.14744 | 127 | 19.63496 | 212 | 54.71347 | 297 | 107.38279 | 382 | 177.64349 | 467 | 265.49500 |
| 43 | 2.25091 | 128 | 19.94539 | 213 | 55.23085 | 298 | 108.10732 | 383 | 178.27778 | 468 | 266.63324 |
| 44 | 2.35682 | 129 | 20.25825 | 214 | 55.75067 | 299 | 108.83409 | 384 | 179.50851 | 469 | 267.77392 |
| 45 | 2.46517 | 130 | 20.57355 | 215 | 56.27292 | 300 | 109.56330 | 385 | 180.44466 | 470 | 268.91703 |
| 46 | 2.57595 | 131 | 20.89128 | 216 | 56.79761 | 301 | 110.29493 | 386 | 181.38326 | 471 | 270.06257 |
| 47 | 2.68917 | 132 | 21.21145 | 217 | 57.32473 | 302 | 111.02901 | 387 | 182.32428 | 472 | 271.21055 |
| 48 | 2.80482 | 133 | 21.53405 | 218 | 57.85429 | 303 | 111.76552 | 388 | 183.26774 | 473 | 272.36097 |
| 49 | 2.92290 | 134 | 21.85909 | 219 | 58.38628 | 304 | 112.50446 | 389 | 184.21364 | 474 | 273.51382 |
| 50 | 3.04342 | 135 | 22.18656 | 220 | 58.92070 | 305 | 113.24584 | 390 | 185.16197 | 475 | 274.66910 |
| 51 | 3.16637 | 136 | 22.51647 | 221 | 59.45756 | 306 | 113.98965 | 391 | 186.11274 | 476 | 275.82682 |
| 52 | 3.29176 | 137 | 22.84881 | 222 | 59.99686 | 307 | 114.73590 | 392 | 187.06594 | 477 | 276.98697 |
| 53 | 3.41959 | 138 | 23.18359 | 223 | 60.53859 | 308 | 115.48458 | 393 | 188.02157 | 478 | 278.14956 |
| 54 | 3.54985 | 139 | 23.52080 | 224 | 61.08275 | 309 | 116.23570 | 394 | 188.97964 | 479 | 279.31459 |
| 55 | 3.68254 | 140 | 23.86045 | 225 | 61.62935 | 310 | 116.98925 | 395 | 189.94015 | 480 | 280.48204 |
| 56 | 3.81767 | 141 | 24.20253 | 226 | 62.17839 | 311 | 117.74524 | 396 | 190.90309 | 481 | 281.65194 |
| 57 | 3.95523 | 142 | 24.54704 | 227 | 62.72985 | 312 | 118.50366 | 397 | 191.86846 | 482 | 282.82426 |
| 58 | 4.09523 | 143 | 24.89399 | 228 | 63.28376 | 313 | 119.26452 | 398 | 192.83627 | 483 | 283.99902 |
| 59 | 4.23766 | 144 | 25.24338 | 229 | 63.84010 | 314 | 120.02781 | 399 | 193.80652 | 484 | 285.17622 |
| 60 | 4.38253 | 145 | 25.59520 | 230 | 64.39887 | 315 | 120.79353 | 400 | 194.77920 | 485 | 286.35585 |
| 61 | 4.52961 | 146 | 25.94945 | 231 | 64.96008 | 316 | 121.56169 | 401 | 195.75431 | 486 | 287.53792 |
| 62 | 4.67957 | 147 | 26.30614 | 232 | 65.52372 | 317 | 122.33229 | 402 | 196.73186 | 487 | 288.72242 |
| 63 | 4.83174 | 148 | 26.66527 | 233 | 66.08979 | 318 | 123.10532 | 403 | 197.71184 | 488 | 289.90936 |
| 64 | 4.98634 | 149 | 27.02683 | 234 | 66.65831 | 319 | 123.88078 | 404 | 198.69426 | 489 | 291.09873 |
| 65 | 5.14338 | 150 | 27.39082 | 235 | 67.22925 | 320 | 124.65865 | 405 | 199.67911 | 490 | 292.29053 |
| 66 | 5.30286 | 151 | 27.75725 | 236 | 67.80263 | 321 | 125.43902 | 406 | 200.66578 | 491 | 293.48477 |
| 67 | 5.46477 | 152 | 28.12611 | 237 | 68.37845 | 322 | 126.22179 | 407 | 201.81112 | 492 | 294.68145 |
| 68 | 5.64911 | 153 | 28.49741 | 238 | 68.95670 | 323 | 127.00699 | 408 | 202.64827 | 493 | 295.88056 |
| 69 | 5.79589 | 154 | 28.87114 | 239 | 69.53739 | 324 | 127.79463 | 409 | 203.64287 | 494 | 297.08210 |
| 70 | 5.96511 | 155 | 29.24731 | 240 | 70.12051 | 325 | 128.58470 | 410 | 204.63989 | 495 | 298.28608 |
| 71 | 6.13676 | 156 | 29.62591 | 241 | 70.70606 | 326 | 129.37721 | 411 | 205.63935 | 496 | 299.49429 |
| 72 | 6.31084 | 157 | 30.00695 | 242 | 71.29405 | 327 | 130.17215 | 412 | 206.64125 | 497 | 300.70134 |
| 73 | 6.48736 | 158 | 30.39042 | 243 | 71.88448 | 328 | 130.96953 | 413 | 207.64558 | 498 | 301.91262 |
| 74 | 6.66631 | 159 | 30.77633 | 244 | 72.47734 | 329 | 131.76934 | 414 | 208.65234 | 499 | 303.12634 |
| 75 | 6.84770 | 160 | 31.16467 | 245 | 73.07263 | 330 | 132.57159 | 415 | 209.66154 | 500 | 304.34250 |
| 76 | 7.03152 | 161 | 31.55544 | 246 | 73.67036 | 331 | 133.37627 | 416 | 210.67318 | 501 | 305.56108 |
| 77 | 7.21778 | 162 | 31.94865 | 247 | 74.27052 | 332 | 134.18339 | 417 | 211.68725 | 502 | 306.78310 |
| 78 | 7.40647 | 163 | 32.34420 | 248 | 74.87312 | 333 | 134.99294 | 418 | 212.69910 | 503 | 308.00556 |
| 79 | 7.59760 | 164 | 32.74238 | 249 | 75.47815 | 334 | 135.80492 | 419 | 213.72269 | 504 | 309.23145 |
| 80 | 7.79116 | 165 | 33.14289 | 250 | 76.08562 | 335 | 136.61934 | 420 | 214.74406 | 505 | 310.45978 |
| 81 | 7.98716 | 166 | 33.54584 | 251 | 76.69552 | 336 | 137.43620 | 421 | 215.76787 | 506 | 311.69054 |
| 82 | 8.18559 | 167 | 33.95123 | 252 | 77.30786 | 337 | 138.25549 | 422 | 216.79411 | 507 | 312.92374 |
| 83 | 8.38647 | 168 | 34.35905 | 253 | 77.92263 | 338 | 139.07721 | 423 | 217.82279 | 508 | 314.15937 |
| 84 | 8.58976 | 169 | 34.76930 | 254 | 78.53984 | 339 | 139.99013 | 424 | 218.85390 | 509 | 315.39743 |
| 85 | 8.79549 | 170 | 35.18199 | 255 | 79.15948 | 340 | 140.72797 | 425 | 219.88745 | 510 | 316.63793 |

*Machinery*

## AREAS OF CIRCLES IN SQUARE INCHES, WHEN DIAMETERS ARE GIVEN IN MILLIMETERS

| Diameter, Millimeters | Area, Square Inches | Diameter, Millimeters | Area, Square Inches | Diameter, Millimeters | Area, Square Inches | Diameter, Millimeters | Area, Square Inches | Diameter, Millimeters | Area, Square Inches | Diameter, Millimeters | Area, Square Inches |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 511 | 317.88087 | 596 | 432.42930 | 681 | 564.56872 | 766 | 714.29915 | 851 | 881.62057 | 936 | 1066.53298 |
| 512 | 319.12624 | 597 | 433.88162 | 682 | 566.22800 | 767 | 716.16537 | 852 | 883.69375 | 937 | 1068.81312 |
| 513 | 320.37404 | 598 | 435.33638 | 683 | 567.88971 | 768 | 718.03404 | 853 | 885.76936 | 938 | 1071.09569 |
| 514 | 321.62428 | 599 | 436.79357 | 684 | 569.55385 | 769 | 719.90514 | 854 | 887.84741 | 939 | 1073.38069 |
| 515 | 322.87695 | 600 | 438.25320 | 685 | 571.22043 | 770 | 721.77867 | 855 | 889.92790 | 940 | 1075.66813 |
| 516 | 324.13206 | 601 | 439.71526 | 686 | 572.88945 | 771 | 723.65464 | 856 | 892.01082 | 941 | 1077.95800 |
| 517 | 325.38960 | 602 | 441.17975 | 687 | 574.56090 | 772 | 725.53304 | 857 | 894.09617 | 942 | 1080.25031 |
| 518 | 326.64958 | 603 | 442.64668 | 688 | 576.23478 | 773 | 727.41387 | 858 | 896.18396 | 943 | 1082.54505 |
| 519 | 327.91200 | 604 | 444.11605 | 689 | 577.91110 | 774 | 729.29715 | 859 | 898.27419 | 944 | 1084.84223 |
| 520 | 329.17684 | 605 | 445.58785 | 690 | 579.58985 | 775 | 731.82856 | 860 | 900.36685 | 945 | 1087.14184 |
| 521 | 330.44413 | 606 | 447.06208 | 691 | 581.27104 | 776 | 733.07099 | 861 | 902.46194 | 946 | 1089.44389 |
| 522 | 331.71384 | 607 | 448.53875 | 692 | 582.95466 | 777 | 734.96157 | 862 | 904.55947 | 947 | 1091.74837 |
| 523 | 332.98599 | 608 | 450.01786 | 693 | 584.64072 | 778 | 736.85458 | 863 | 906.65943 | 948 | 1094.05528 |
| 524 | 334.26058 | 609 | 451.49940 | 694 | 586.32921 | 779 | 738.75002 | 864 | 908.76183 | 949 | 1096.36463 |
| 525 | 335.52760 | 610 | 452.98337 | 695 | 588.02014 | 780 | 740.64790 | 865 | 910.86666 | 950 | 1098.67642 |
| 526 | 336.81706 | 611 | 454.34804 | 696 | 589.71350 | 781 | 742.54822 | 866 | 912.97393 | 951 | 1100.99064 |
| 527 | 338.09895 | 612 | 455.95862 | 697 | 591.40930 | 782 | 744.45097 | 867 | 915.08363 | 952 | 1103.30730 |
| 528 | 339.38327 | 613 | 457.44990 | 698 | 593.10753 | 783 | 746.35615 | 868 | 917.19577 | 953 | 1105.62639 |
| 529 | 340.67003 | 614 | 458.94362 | 699 | 594.80819 | 784 | 748.26377 | 869 | 919.31034 | 954 | 1107.94791 |
| 530 | 341.95923 | 615 | 460.43976 | 700 | 596.51130 | 785 | 750.17382 | 870 | 921.42735 | 955 | 1110.27187 |
| 531 | 343.25086 | 616 | 461.93835 | 701 | 598.21683 | 786 | 752.08631 | 871 | 923.54679 | 956 | 1112.59826 |
| 532 | 344.54492 | 617 | 463.43936 | 702 | 599.92480 | 787 | 754.00123 | 872 | 925.57867 | 957 | 1114.92709 |
| 533 | 345.84142 | 618 | 464.94281 | 703 | 601.63521 | 788 | 755.91859 | 873 | 927.79298 | 958 | 1117.25836 |
| 534 | 347.14035 | 619 | 466.44870 | 704 | 603.34804 | 789 | 757.83838 | 874 | 929.91972 | 959 | 1119.59205 |
| 535 | 348.44172 | 620 | 467.95702 | 705 | 605.06332 | 790 | 759.76061 | 875 | 932.04890 | 960 | 1121.92819 |
| 536 | 349.74953 | 621 | 469.46778 | 706 | 606.78103 | 791 | 761.68527 | 876 | 934.18052 | 961 | 1124.26675 |
| 537 | 351.05176 | 622 | 470.98097 | 707 | 608.50117 | 792 | 763.61237 | 877 | 936.31457 | 962 | 1126.60776 |
| 538 | 352.36044 | 623 | 472.49660 | 708 | 610.22375 | 793 | 765.54190 | 878 | 938.45105 | 963 | 1128.95119 |
| 539 | 353.67154 | 624 | 474.01466 | 709 | 611.94876 | 794 | 767.47387 | 879 | 940.58997 | 964 | 1131.29707 |
| 540 | 354.98509 | 625 | 475.53515 | 710 | 613.67621 | 795 | 769.40827 | 880 | 942.73132 | 965 | 1133.64537 |
| 541 | 356.30706 | 626 | 477.05808 | 711 | 615.40609 | 796 | 771.34510 | 881 | 944.87511 | 966 | 1135.99611 |
| 542 | 357.61948 | 627 | 478.58344 | 712 | 617.13841 | 797 | 773.28438 | 882 | 947.02133 | 967 | 1138.34929 |
| 543 | 358.94032 | 628 | 480.11125 | 713 | 618.87316 | 798 | 775.22608 | 883 | 949.16999 | 968 | 1140.70490 |
| 544 | 360.26360 | 629 | 481.64148 | 714 | 620.61035 | 799 | 777.17022 | 884 | 951.32109 | 969 | 1143.06295 |
| 545 | 361.58932 | 630 | 483.17415 | 715 | 622.34998 | 800 | 779.16800 | 885 | 953.47461 | 970 | 1145.42343 |
| 546 | 362.91747 | 631 | 484.70925 | 716 | 624.09203 | 801 | 781.06580 | 886 | 955.63058 | 971 | 1147.78634 |
| 547 | 364.24806 | 632 | 486.24679 | 717 | 625.83652 | 802 | 783.01725 | 887 | 957.78897 | 972 | 1150.15169 |
| 548 | 365.58108 | 633 | 487.78676 | 718 | 627.58345 | 803 | 784.97113 | 888 | 959.94980 | 973 | 1152.51948 |
| 549 | 366.91653 | 634 | 489.32917 | 719 | 629.33261 | 804 | 786.92744 | 889 | 962.11307 | 974 | 1154.88970 |
| 550 | 368.25442 | 635 | 490.87401 | 720 | 631.08460 | 805 | 788.88619 | 890 | 964.27877 | 975 | 1157.26235 |
| 551 | 369.59474 | 636 | 492.42129 | 721 | 632.83838 | 806 | 790.84737 | 891 | 966.44691 | 976 | 1159.63744 |
| 552 | 370.93750 | 637 | 493.97100 | 722 | 634.59550 | 807 | 792.81099 | 892 | 968.61748 | 977 | 1162.01496 |
| 553 | 372.28270 | 638 | 495.52315 | 723 | 636.35460 | 808 | 794.77704 | 893 | 970.79048 | 978 | 1164.39492 |
| 554 | 373.63033 | 639 | 497.07773 | 724 | 638.11613 | 809 | 796.74553 | 894 | 972.96592 | 979 | 1166.77732 |
| 555 | 374.98039 | 640 | 498.63475 | 725 | 639.88010 | 810 | 798.71645 | 895 | 975.14380 | 980 | 1169.16214 |
| 556 | 376.33289 | 641 | 500.19420 | 726 | 641.64651 | 811 | 800.68981 | 896 | 977.32411 | 981 | 1171.54941 |
| 557 | 377.68782 | 642 | 501.75608 | 727 | 643.41534 | 812 | 802.66560 | 897 | 979.50685 | 982 | 1173.93910 |
| 558 | 379.04519 | 643 | 503.32040 | 728 | 645.18662 | 813 | 804.64383 | 898 | 981.69203 | 983 | 1176.33123 |
| 559 | 380.40499 | 644 | 504.88716 | 729 | 646.96023 | 814 | 806.62449 | 899 | 983.87965 | 984 | 1178.72580 |
| 560 | 381.76723 | 645 | 506.45635 | 730 | 648.73647 | 815 | 808.60758 | 900 | 986.06970 | 985 | 1181.12280 |
| 561 | 383.13190 | 646 | 508.02797 | 731 | 650.51505 | 816 | 810.59311 | 901 | 988.26218 | 986 | 1183.52224 |
| 562 | 384.49901 | 647 | 509.60203 | 732 | 652.29606 | 817 | 812.58108 | 902 | 990.45710 | 987 | 1185.92411 |
| 563 | 385.86855 | 648 | 511.17853 | 733 | 654.07950 | 818 | 814.57148 | 903 | 992.65445 | 988 | 1188.32842 |
| 564 | 387.24052 | 649 | 512.75746 | 734 | 655.86539 | 819 | 816.56431 | 904 | 994.85424 | 989 | 1190.73516 |
| 565 | 388.61493 | 650 | 514.33882 | 735 | 657.65370 | 820 | 818.55958 | 905 | 997.05646 | 990 | 1193.14433 |
| 566 | 389.99178 | 651 | 515.92262 | 736 | 659.44445 | 821 | 820.55729 | 906 | 999.26132 | 991 | 1195.55594 |
| 567 | 391.37106 | 652 | 517.50885 | 737 | 661.23764 | 822 | 822.55743 | 907 | 1001.46821 | 992 | 1197.96999 |
| 568 | 392.75277 | 653 | 519.09752 | 738 | 663.03326 | 823 | 824.56000 | 908 | 1003.67773 | 993 | 1200.38647 |
| 569 | 394.13692 | 654 | 520.68862 | 739 | 664.83132 | 824 | 826.56501 | 909 | 1005.88970 | 994 | 1202.80538 |
| 570 | 395.52351 | 655 | 522.28216 | 740 | 666.63181 | 825 | 828.57245 | 910 | 1008.10409 | 995 | 1205.22673 |
| 571 | 396.91253 | 656 | 523.87813 | 741 | 668.43473 | 826 | 830.58203 | 911 | 1010.32092 | 996 | 1207.65051 |
| 572 | 398.30398 | 657 | 525.47654 | 742 | 670.24009 | 827 | 832.59464 | 912 | 1012.54019 | 997 | 1210.07673 |
| 573 | 399.69787 | 658 | 527.07738 | 743 | 672.04789 | 828 | 834.60939 | 913 | 1014.76189 | 998 | 1212.50538 |
| 574 | 401.09419 | 659 | 528.68066 | 744 | 673.85812 | 829 | 836.62657 | 914 | 1016.98602 | 999 | 1214.93647 |
| 575 | 402.49295 | 660 | 530.28637 | 745 | 675.67078 | 830 | 838.64619 | 915 | 1019.21259 | 1000 | 1217.37000 |
| 576 | 403.89414 | 661 | 531.89451 | 746 | 677.48588 | 831 | 840.66824 | 916 | 1021.44160 | 1001 | 1219.80575 |
| 577 | 405.29777 | 662 | 533.50509 | 747 | 679.30341 | 832 | 842.69273 | 917 | 1023.67304 | 1002 | 1222.24434 |
| 578 | 406.70383 | 663 | 535.11811 | 748 | 681.12338 | 833 | 844.71965 | 918 | 1025.90691 | 1003 | 1224.68517 |
| 579 | 408.11233 | 664 | 536.73356 | 749 | 682.94578 | 834 | 846.74900 | 919 | 1028.14322 | 1004 | 1227.12843 |
| 580 | 409.52326 | 665 | 538.35144 | 750 | 684.77062 | 835 | 848.78079 | 920 | 1030.38196 | 1005 | 1229.57413 |
| 581 | 410.93663 | 666 | 539.97176 | 751 | 686.59789 | 836 | 850.81502 | 921 | 1032.62314 | 1006 | 1232.02226 |
| 582 | 412.35243 | 667 | 541.59452 | 752 | 688.42760 | 837 | 852.85168 | 922 | 1034.86675 | 1007 | 1234.47283 |
| 583 | 413.77067 | 668 | 543.21971 | 753 | 690.25974 | 838 | 854.89077 | 923 | 1037.11280 | 1008 | 1236.92583 |
| 584 | 415.19134 | 669 | 544.84733 | 754 | 692.09432 | 839 | 856.93230 | 924 | 1039.36128 | 1009 | 1239.38126 |
| 585 | 416.61444 | 670 | 546.47739 | 755 | 693.93133 | 840 | 858.97627 | 925 | 1041.61220 | 1010 | 1241.83913 |
| 586 | 418.03998 | 671 | 548.10988 | 756 | 695.77078 | 841 | 861.02670 | 926 | 1043.86555 | 1011 | 1244.29944 |
| 587 | 419.46796 | 672 | 549.74481 | 757 | 697.61266 | 842 | 863.07150 | 927 | 1046.12134 | 1012 | 1246.76218 |
| 588 | 420.89837 | 673 | 551.38217 | 758 | 699.45697 | 843 | 865.12277 | 928 | 1048.37956 | 1013 | 1249.22735 |
| 589 | 422.33121 | 674 | 553.02197 | 759 | 701.30372 | 844 | 867.17647 | 929 | 1050.64022 | 1014 | 1251.69496 |
| 590 | 423.76649 | 675 | 554.66420 | 760 | 703.15291 | 845 | 869.23261 | 930 | 1052.90331 | 1015 | 1254.16500 |
| 591 | 425.20421 | 676 | 556.30887 | 761 | 705.00453 | 846 | 871.29118 | 931 | 1055.16883 | 1016 | 1256.63748 |
| 592 | 426.64435 | 677 | 557.95597 | 762 | 706.85858 | 847 | 873.35419 | 932 | 1057.43679 | 1017 | 1259.11239 |
| 593 | 428.08694 | 678 | 559.60551 | 763 | 708.71507 | 848 | 875.41563 | 933 | 1059.70719 | 1018 | 1261.58974 |
| 594 | 429.53196 | 679 | 561.25748 | 764 | 710.57399 | 849 | 877.48151 | 934 | 1061.98002 | 1019 | 1264.06953 |
| 595 | 430.97941 | 680 | 562.91188 | 765 | 712.43535 | 850 | 879.54982 | 935 | 1064.25528 | 1020 | 1266.56174 |

*Machinery*

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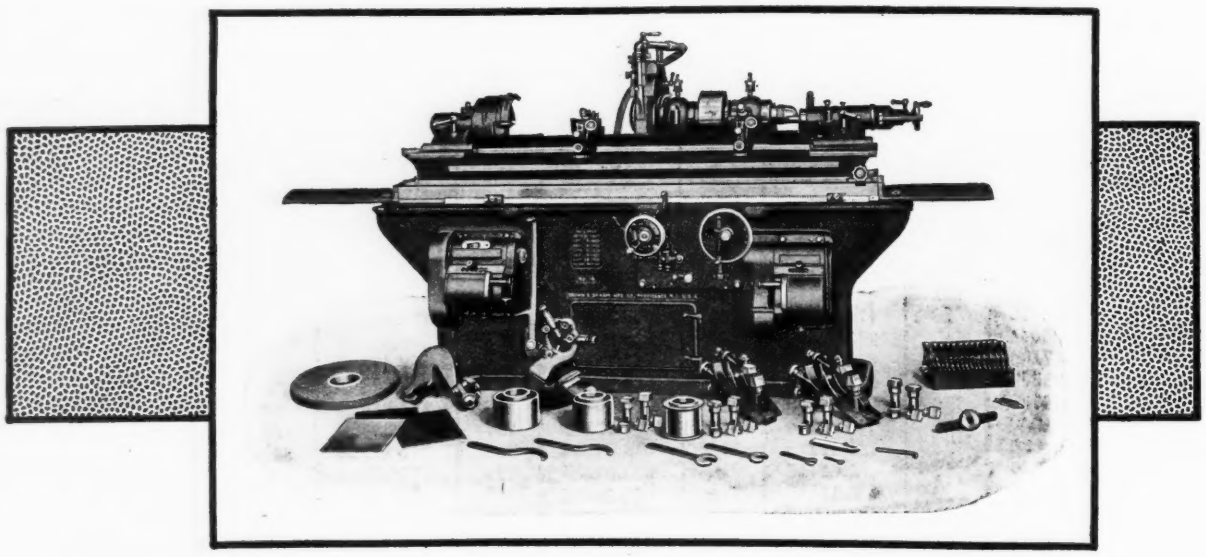

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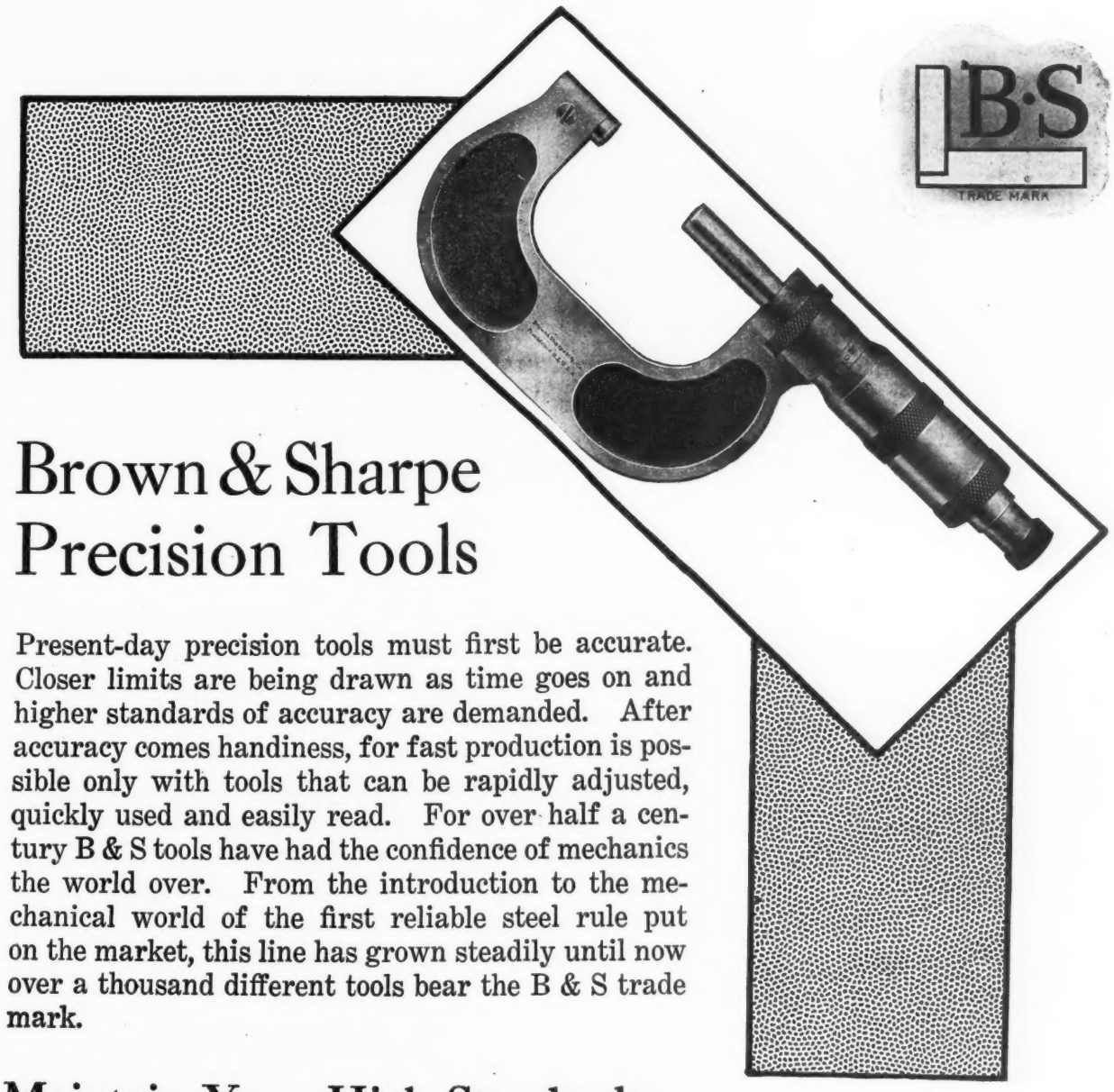
*OF EVERY BROWN & SHARPE PRODUCT*

# Without Sacrifice of Accuracy

## *With B & S Machinists' Tools*




## Brown & Sharpe Precision Tools

Present-day precision tools must first be accurate. Closer limits are being drawn as time goes on and higher standards of accuracy are demanded. After accuracy comes handiness, for fast production is possible only with tools that can be rapidly adjusted, quickly used and easily read. For over half a century B & S tools have had the confidence of mechanics the world over. From the introduction to the mechanical world of the first reliable steel rule put on the market, this line has grown steadily until now over a thousand different tools bear the B & S trade mark.

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**Use B & S Precision Tools**

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## MFG. COMPANY

**Providence, Rhode Island**
**U. S. A.**

The Careful Use of
**Brown & Sharpe Tools**
Makes Accuracy Certain

## AREAS OF CIRCLES IN SQUARE INCHES, WHEN DIAMETERS ARE GIVEN IN MILLIMETERS

| Diameter, Millimeters | Area, Square Inches | Diameter, Millimeters | Area, Square Inches | Diameter, Millimeters | Area, Square Inches | Diameter, Millimeters | Area, Square Inches | Diameter, Millimeters | Area, Square Inches | Diameter, Millimeters | Area, Square Inches |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1021 | 1269.03640 | 1055 | 1354.96324 | 1089 | 1443.70464 | 1123 | 1535.26061 | 1157 | 1629.63113 | 1191 | 1726.81621 |
| 1022 | 1271.52348 | 1056 | 1357.53311 | 1090 | 1446.35729 | 1124 | 1537.99604 | 1158 | 1632.44934 | 1192 | 1729.71720 |
| 1023 | 1274.01300 | 1057 | 1360.10541 | 1091 | 1449.01238 | 1125 | 1540.73390 | 1159 | 1635.26999 | 1193 | 1732.62063 |
| 1024 | 1276.50496 | 1058 | 1362.68015 | 1092 | 1451.66989 | 1126 | 1543.47420 | 1160 | 1638.09307 | 1194 | 1735.52649 |
| 1025 | 1278.99935 | 1059 | 1365.25732 | 1093 | 1454.32985 | 1127 | 1546.21694 | 1161 | 1640.91858 | 1195 | 1738.43479 |
| 1026 | 1281.49618 | 1060 | 1367.83693 | 1094 | 1456.99224 | 1128 | 1548.96211 | 1162 | 1643.74653 | 1196 | 1741.34552 |
| 1027 | 1283.99544 | 1061 | 1370.41897 | 1095 | 1459.65706 | 1129 | 1551.70971 | 1163 | 1646.57692 | 1197 | 1744.25869 |
| 1028 | 1286.49713 | 1062 | 1373.00345 | 1096 | 1462.32432 | 1130 | 1554.45975 | 1164 | 1649.40974 | 1198 | 1747.17429 |
| 1029 | 1289.00126 | 1063 | 1375.59036 | 1097 | 1464.99401 | 1131 | 1557.21222 | 1165 | 1652.24499 | 1199 | 1750.09232 |
| 1030 | 1291.50783 | 1064 | 1378.17970 | 1098 | 1467.66614 | 1132 | 1559.96713 | 1166 | 1655.08268 | 1200 | 1753.01280 |
| 1031 | 1294.01683 | 1065 | 1380.77148 | 1099 | 1470.34070 | 1133 | 1562.72447 | 1167 | 1657.92281 | 1201 | 1755.93570 |
| 1032 | 1296.52826 | 1066 | 1383.36570 | 1100 | 1473.01770 | 1134 | 1565.48425 | 1168 | 1660.76537 | 1202 | 1758.88804 |
| 1033 | 1299.04213 | 1067 | 1385.96235 | 1101 | 1475.69713 | 1135 | 1568.24646 | 1169 | 1663.61036 | 1203 | 1761.78882 |
| 1034 | 1301.55843 | 1068 | 1388.56143 | 1102 | 1478.37899 | 1136 | 1571.01111 | 1170 | 1666.45779 | 1204 | 1764.71902 |
| 1035 | 1304.07717 | 1069 | 1391.16295 | 1103 | 1481.06329 | 1137 | 1573.77819 | 1171 | 1669.30765 | 1205 | 1767.65167 |
| 1036 | 1306.59835 | 1070 | 1393.76691 | 1104 | 1483.75003 | 1138 | 1576.54771 | 1172 | 1672.15995 | 1206 | 1770.58675 |
| 1037 | 1309.12195 | 1071 | 1396.37330 | 1105 | 1486.43920 | 1139 | 1579.31966 | 1173 | 1675.01468 | 1207 | 1773.52426 |
| 1038 | 1311.64800 | 1072 | 1398.98212 | 1106 | 1489.13080 | 1140 | 1582.09405 | 1174 | 1677.87185 | 1208 | 1776.46421 |
| 1039 | 1314.17647 | 1073 | 1401.59338 | 1107 | 1491.82484 | 1141 | 1584.87087 | 1175 | 1680.73145 | 1209 | 1779.40659 |
| 1040 | 1316.70739 | 1074 | 1404.20707 | 1108 | 1494.52132 | 1142 | 1587.65012 | 1176 | 1683.59349 | 1210 | 1782.35141 |
| 1041 | 1319.24073 | 1075 | 1406.82320 | 1109 | 1497.22023 | 1143 | 1590.43181 | 1177 | 1686.45796 | 1211 | 1784.20303 |
| 1042 | 1321.77652 | 1076 | 1409.44176 | 1110 | 1499.92157 | 1144 | 1593.21594 | 1178 | 1689.32487 | 1212 | 1788.24835 |
| 1043 | 1324.31473 | 1077 | 1412.06276 | 1111 | 1502.62535 | 1145 | 1596.00250 | 1179 | 1692.19421 | 1213 | 1791.20047 |
| 1044 | 1326.85538 | 1078 | 1414.68619 | 1112 | 1505.33156 | 1146 | 1598.79149 | 1180 | 1695.06598 | 1214 | 1794.15503 |
| 1045 | 1329.39847 | 1079 | 1417.31206 | 1113 | 1508.04021 | 1147 | 1601.58292 | 1181 | 1697.94019 | 1215 | 1797.11202 |
| 1046 | 1331.94399 | 1080 | 1419.94036 | 1114 | 1510.75130 | 1148 | 1604.37679 | 1182 | 1700.81684 | 1216 | 1800.07145 |
| 1047 | 1334.49195 | 1081 | 1422.57110 | 1115 | 1513.46481 | 1149 | 1607.17309 | 1183 | 1703.69592 | 1217 | 1803.03331 |
| 1048 | 1337.04234 | 1082 | 1425.20427 | 1116 | 1516.18077 | 1150 | 1609.97182 | 1184 | 1706.57743 | 1218 | 1805.99761 |
| 1049 | 1339.59516 | 1083 | 1427.83988 | 1117 | 1518.89915 | 1151 | 1612.77299 | 1185 | 1709.46138 | 1219 | 1808.96434 |
| 1050 | 1342.15042 | 1084 | 1430.47792 | 1118 | 1521.61997 | 1152 | 1615.57659 | 1186 | 1712.34777 | 1220 | 1811.93350 |
| 1051 | 1344.70811 | 1085 | 1433.22098 | 1119 | 1524.34323 | 1153 | 1618.38263 | 1187 | 1715.23659 | .... | ..... |
| 1052 | 1347.26824 | 1086 | 1435.76130 | 1120 | 1527.06892 | 1154 | 1621.19110 | 1188 | 1718.12784 | .... | ..... |
| 1053 | 1349.83081 | 1087 | 1438.40665 | 1121 | 1529.79705 | 1155 | 1624.00201 | 1189 | 1721.02153 | .... | ..... |
| 1054 | 1352.39581 | 1088 | 1441.05443 | 1122 | 1532.52761 | 1156 | 1626.81535 | 1190 | 1723.91765 | .... | ..... |

*Machinery*

## TABLE CONVERTING MILLIMETER DIAMETERS INTO SQUARE INCHES

The accompanying table gives the areas of circles, in square inches, when their diameters are given in millimeters. In view of the increasing demand for work measured by the metric system, caused by our growing foreign trade, conversion tables of this kind are of value in both the shop and the drafting-room.

Leeds, England A. LANE

## PERSONALS

H. A. Runge, vice-president of the Internations Commercial Corporation, New York City, has resigned his position.

H. D. Gumpper, until recently associated with the Emerson Co., New York City, efficiency engineer, is now with W. F. Hebard in the electric truck sales department of the Buda Co., Chicago, Ill.

James W. Barr, formerly the Eastern representative of the Cincinnati Milling Machine Co., Cincinnati, Ohio, is now general machine tool salesman for the Vandyck-Churchill Co. of New York City.

W. J. Radcliffe, vice-president and general manager of the E. A. Kinsey Co., Cincinnati, Ohio, was elected president and general manager of the company at a meeting of the board of directors January 17.

L. C. Parrott, for four years assistant purchasing agent of the Standard Parts Co. (formerly the Standard Welding Co.), Cleveland, Ohio, has resigned his position to become purchasing agent of the Otis Steel Co. of Cleveland.

H. A. Shier, who for the past seven years has represented the Bethlehem Steel Co. in southern Ohio, has resigned and taken a position with the Onondaga Steel Co., Inc., Syracuse, N. Y., as representative in southern Ohio and western Pennsylvania.

A luncheon was given at the Bankers Club, New York City, January 11, by Arthur Williams, president of the American Museum of Safety, in honor of the new director, Arthur H. Young, and in recognition of the services rendered by acting-director, A. A. Hopkins.

D. M. Kagay has taken the position of manager of the publication department with S. F. Bowser & Co., Inc., Fort Wayne, Ind. Mr. Kagay was formerly advertising manager of the Richards-Wilcox Mfg. Co., Aurora, Ill., and editor of two house organs published by the company.

H. D. Savage, vice-president of the American Arch Co., has been appointed manager of sales of the industrial department of the Locomotive Pulverized Fuel Co., with offices at 30 Church St., New York City. He will continue to act in the capacity of vice-president of the American Arch Co.

Paul R. Ketzer, formerly Eastern manager of the Metalwood Mfg. Co., Detroit, Mich., has gone into business for himself and organized a company called the Ketzer Machinery Co., which will specialize in power, steam, hydraulic and special machinery and tools. The office of the company is in the Bourse, Philadelphia, Pa.

H. H. Gildner, for the past three years chief engineer of the S. K. F. Ball Bearing Co., Hartford, Conn., has resigned and joined F. R. Blair & Co., Inc., 50 Church St., New York City, as manager of the company's "Flexite" department. Mr. Gildner will devote himself to the development and sale of "Flexite" universal joints and couplings.

Gorham C. Parker has resigned his position of sales manager for the T. R. Almond Mfg. Co., Ashburnham, Mass., and organized the Parker Mfg. Co. of Detroit, Mich. The company will manufacture a complete line of three-jawed keyed type of drill chucks. Mr. Parker was formerly sales manager for the Jacobs Mfg. Co. of Hartford, Conn., and is well known in the machinery trade.

A. L. Humphrey, vice-president of the Union Switch & Signal Co., has been elected president of the company. The control of the company will be taken over by the Westinghouse Air Brake Co. and the capitalization will be increased from $20,000,000 to $30,000,000. Mr. Humphrey has had charge of the ammunition contracts secured from several foreign governments within the past two years, amounting to about $20,000,000.

Carl M. Hansen, widely known through his activities in connection with accident prevention, compensation and casualty insurance, has been appointed chairman of the National Association of Manufacturers Committee for accident prevention and workmen's compensation. Mr. Hansen is the author of "Universal Safety Standards," a work of thirteen volumes, and has been a frequent contributor to technical journals on subjects relating to compensation, prevention and occupational diseases.

J. G. Blunt was recently appointed mechanical engineer of the American Locomotive Co. with headquarters at Schenectady, N. Y. Mr. Blunt took the mechanical engineering course at the University of Michigan, and after spending four years as machinist and draftsman with various manufacturing concerns, took a position in 1897 as draftsman with the Brooks

# This is Accurate Milling

It is milling crank-case surfaces 6⅜″ x 24″ at a 90° angle in two settings. The work is done on a Cincinnati No. 3 Vertical Milling Machine, with a 9″ diameter cutter, operating at 180 R. P. M., or 424 feet per minute, and at a feed of 12½″ per minute, including both longitudinal and transverse feed. Error is kept within the 0.0015″ limit allowed for both surfaces.

Two "No. 3's" are on this job. Average production from each machine, each operation, 100 crank-cases in 10 hours, and the work as difficult as you can find.

## The Cincinnati No. 3 Vertical Milling Machine

"Cincinnati" milling helps make the Cadillac Motor the accurate motor it is. It will prove equally efficient for your work. Ask us to show you.

## THE CINCINNATI MILLING MACHINE CO.

CINCINNATI, OHIO, U. S. A.

Locomotive Works at Dunkirk, N. Y., and later became chief draftsman of the company. When the engineering work of all the company's plants was consolidated at Schenectady Mr. Blunt was transferred as engineer of the drafting department and later was appointed superintendent of the general drawing-room, which position he held at the time of his appointment.

Charles M. Hammond, president and practical head of the Hammond Steel & Forging Co., Syracuse, N. Y., formerly connected with the Halcomb Steel Co. and the Sanderson Steel Co. of Syracuse, has sold his interest in the Hammond Steel & Forging Co. and retired to become president of a new concern, which will be located in Auburn, N. Y., known as the Cayuga Tool Steel Co., Ltd. Mr. Hammond will have associated with him some of the most prominent interests in America and Sweden. It is the purpose of the new company to erect and operate rolling mills, a hammer plant, crucible furnaces, electric furnaces and open-hearth furnaces for the manufacture of high-grade steel. It is the intention to specialize on high-grade tool and alloy steels.

## OBITUARIES

Philip G. Fosdick, president of the Cincinnati Gear Co., Cincinnati, Ohio, died January 22, in Florida, aged fifty-nine years. Mr. Fosdick organized the Fosdick Machine Tool Co. of Cincinnati, but disposed of his interest in the company several years ago.

Col. Herbert Hughes, director of William Jessop & Sons, Inc., steel makers of Sheffield, England, and 91 John St., New York City, died recently at the age of sixty-four. Colonel Hughes represented the British government at the International Conference on Trademarks, held at Washington a few years ago, and was well known in commercial circles in America.

William E. Leard of New Brighton, Pa., died at Southern Pines, N. C., December 17, aged seventy-four years. Shortly after the close of the Civil War he engaged in the manufacture of drill presses in Cincinnati, Ohio. In 1882 he located a plant in New Brighton, Pa., for the manufacture of connecting-rods, strap joints, crankshafts and machine keys.

Alfred B. Jenkins, president of Jenkins Bros., New York City, manufacturers of valves and mechanical rubber goods, died at his home in West Orange, N. J., December 29, aged sixty-eight years. Mr. Jenkins formed a partnership with his brother, Charles Jenkins, in 1872, and the business has been carried on under the same name and management since. Mr. Jenkins was a veteran of the Civil War, and was prominent in the civic life of West Orange.

Charles C. Ramsey, president of the Crucible Steel Co. of America, died January 11, following an illness of five weeks with pneumonia, aged fifty-four years. Mr. Ramsey started his business career as a stenographer and was promoted from one position to another until he became manager of the Philadelphia branch of Park Bros. & Co. Later he was made manager of the New York City branch of that company, which post he held until the organization of the Crucible Steel Co. of America. After serving for a time with R. E. Jennings in the management of the Eastern business of the company, he was made fourth vice-president and manager of the Eastern office. He was elected president in 1910, following the death of Frank B. Smith, then president. Mr. Ramsey left a widow and three children.

Ellis J. Hannum, secretary of the Newton Machine Tool Works, Inc., Philadelphia, Pa., died suddenly January 7, following a short illness. Although Mr. Hannum had not enjoyed the best of health during the past few years, his sudden death was unexpected. Mr. Hannum entered the employ of the Newton Machine Tool Works, Inc., as a boy, and from the beginning showed exceptional talent for freehand sketching, drawing and similar work, and it was natural that he should have showed a preference for the drafting and engineering departments in which he progressed rapidly under the direction of the late Mr. Newton. During the past two years failing health had caused him to relinquish his active duties in the engineering department, and during this time he had acted in an advisory capacity to the drafting department.

## COMING EVENTS

**February 13.**—Section meeting of the Providence Engineering Society, Providence, R. I. Luther D. Burlingame will read a paper "The Units of Measurements in Relation to the Metric System." Herman R. Simmons, secretary, 160 Chapel St., Saylesville, R. I.

**February 21-24.**—Tenth annual convention of the National Society for the Promotion of Industrial Education, at Indianapolis, Ind., Hotel Claypool, headquarters. Alvin E. Dodd, secretary, 140 W. 42nd St., New York City.

**February 22.**—Monthly meeting of the Rochester Society of Technical Draftsmen, in Rooms 131-137, Sibley Block, 328 Main St., E., Rochester, N. Y. O. L. Angevine, Jr., secretary, 857 Genesee St., Rochester.

**May 21-22.**—Spring convention of the National Machine Tool Builders' Association in Cincinnati, Ohio. Charles E. Hildreth, general manager, Worcester, Mass.

**May 22-25.**—Spring meeting of the American Society of Mechanical Engineers in Cincinnati, Ohio. Calvin W. Rice, secretary, 29 W. 39th St., New York City.

**August 30-Sept. 1.**—Ninth annual convention of the American Railway Tool Foreman's Association, Chicago, Ill., Sherman Hotel, headquarters. C. N. Thulin, secretary-treasurer, 935 Peoples Gas Bldg., Chicago, Ill.

## SOCIETIES, SCHOOLS AND COLLEGES

**Purchasing Agents' Association of Rochester,** Rochester, N. Y., decided at a recent meeting to permit representatives of manufacturers to appear at its meetings and address its members. The belief is expressed that the members will derive a great deal of benefit from demonstrations made by representatives of manufacturing concerns. Meetings of the association are held the fourth Friday of each month. Secretary, E. A. Schelve, Bosch & Lomb Optical Co., Rochester, N. Y.

**University of Illinois, Urbana, Ill.,** maintains fourteen Engineering Experiment Station research fellowships. One other such fellowship has been established under the patronage of the Illinois Gas Association. These fellowships, for each of which there is an annual stipend of $500, are open to graduates of approved American and foreign universities and technical schools. Appointments to these fellowships are made for two consecutive collegiate years and must be accepted under those terms. At the expiration of this period, if all requirements have been met, the degree of Master of Science will be conferred. Additional information may be obtained by addressing the director.

## NEW BOOKS AND PAMPHLETS

**Operating Details of Gas Producers.** By R. H. Fernald. 74 pages, 6 by 9 inches. Published by the Bureau of Mines, Department of the Interior, Washington, D. C., as Bulletin No. 109.

**Subsidence Resulting from Mining.** By L. E. Young and H. H. Stoek. 205 pages, 6 by 9 inches; illustrated. Published by the Engineering Experiment Station, University of Illinois, Urbana, Ill., as Bulletin No. 91.

**Different Methods of Workmen's Compensation Insurance.** By Edison S. Lott, president, United States Casualty Co. 14 pages, 6 by 9 inches. Distributed by United States Casualty Co., 80 Maiden Lane, New York City.

**Measurement of Electrical Energy, Electricity Meters, Rates for Electrical Energy.** By George C. Schaad and C. A. Johnson. 93 pages, 6 by 9 inches; illustrated. Published by the University Engineering Experiment Station, University of Kansas, Lawrence, Kan., as Engineering Bulletin No. 8.

**Statistics of Railways, 1905-1915.** 57 pages, 6 by 9 inches. Published by the Bureau of Railway Economics (established by railways of the United States for the scientific study of transportation problems). The bulletin is designated as consecutive No. 103, miscellaneous series No. 26, and is distributed by the Bureau of Railway Economics, Washington, D. C.

**Manual for Engineers.** Compiled by Charles E. Ferris. 220 pages, 2¾ by 5½ inches. Published by the University Press, Knoxville, Tenn. Price, 50 cents.

This convenient compilation of tables and other data for engineers and business men has just appeared in the twentieth edition, which is an indication of its practical worth. Prof. Ferris, professor of mechanical engineering of the University of Tennessee, the compiler of the work, selected the data with an eye to presenting in small compass that which would be of the greatest general value to the average user.

**Design of Marine Engines and Auxiliaries.** By Edward M. Bragg. 183 pages, 6 by 9 inches; 110 illustrations and folding plates. Published by D. Van Nostrand Co., New York City. Price, $3 net.

This work deals with the reciprocating marine engine, taking up the determination of cylinder dimensions, design of engine parts, engine balancing, condensers and air pumps, turning engines and reversing engines. Much time and effort have been expended on the section on engine balancing, which treats of single-cylinder and multiple-cylinder engines up to six cylinders.

**Molybdenum, Its Ores and Their Concentration, with a Discussion of Markets, Prices, and Uses.** By Frederick W. Horton. Published by the U. S. Bureau of Mines, Department of the Interior, as Bulletin No. 111. Price, 30 cents. Address, Superintendent of Documents, Government Printing Office, Washington, D. C.

There are large deposits of low-grade molybdenum ore in the United States, but there has been no production worth mentioning prior to 1914. In fact, there was no output of molybdenum ore in this country except in 1905, 1906 and 1907, when a few small lots of molybdenite and wulfenite were marketed. In view of the value of molybdenum in imparting characteristics to alloy steels roughly similar to those produced by tungsten, the Bureau of Mines has undertaken to ascertain the character and extent of deposits of molybdenum ore in the United States.

**Elementary Mathematics for Engineers.** By Ernest H. Sprague. 236 pages, 4½ by 7 inches. Published by Scott, Greenwood & Son, London, England, and distributed in the United States by D. Van Nostrand Co., New York City. Price, $1.50 net.

The aim of this work is to present the vast subject of mathematics in a way to avoid extreme simplicity on one hand and profundity on the other. The aim has been to cover a wide field in a small compass, to bring out the essential parts, and to introduce useful matter as a means of illustrating principles. The work deals with arithmetical operations, algebra, plane trigonometry, mensuration, spherical trigonometry, algebraic geometry, differential calculus, integral calculus, mathematical data and formulas, etc. It is extremely condensed, and while not to be recommended to a beginner, the work should be extremely useful to those who have good ground work and wish to extend their knowledge of mathematics or to refresh their memories.

**Elementary Cams.** By Franklin DeRonde Furman. 87 pages, 6 by 9 inches; 69 illustrations. Published by John Wiley & Sons, Inc., New York City. Price, $1.25 net.

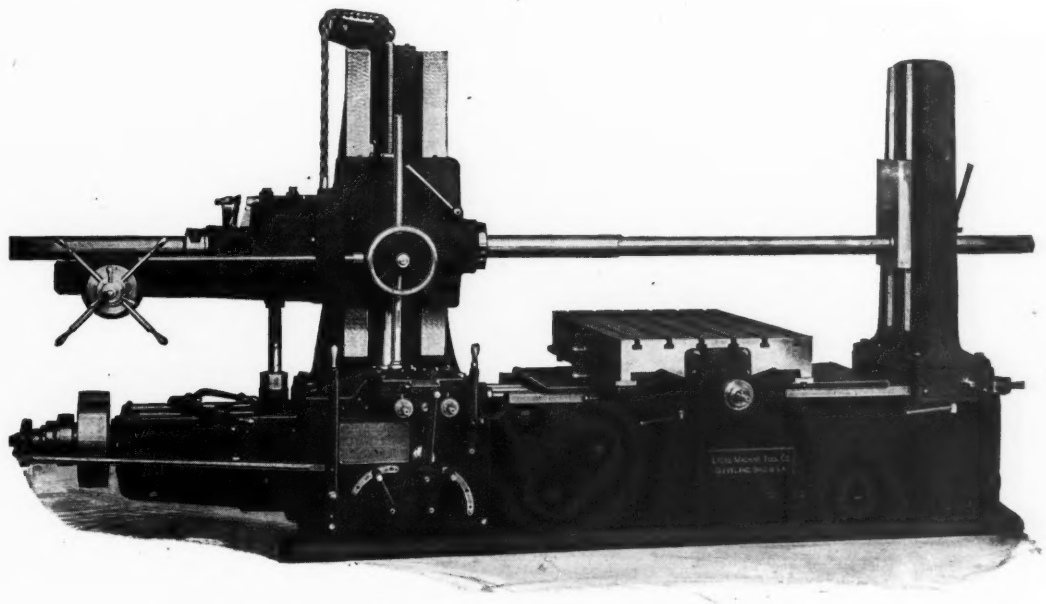
Cams are defined as rotating or oscillating pieces of mechanism having specially formed surfaces against which a follower slides or rolls and thus receives a reciprocating or intermittent motion such as cannot be generally obtained by gear wheels or link motions. The author states in his preface that the introduction of automatic machinery in which cams are largely used calls strongly for a comprehensive method of technical analysis. The work, written first in the form of lesson papers for Prof. Furman's students in Stevens Institute of Technology, has been published because of the belief of a general need for a book on the subject. It is divided into five sections, treating of definitions and classification, method of construction of base curves in common use, cam problems and exercise problems, timing and interference of cams, and cams for reproducing given curves or figures. The work is one that we would recommend to anyone wanting to study the principles of cam design.

**Awakening of Business.** By Edward N. Hurley. 237 pages, 5 by 7¾ inches. Published by Doubleday, Page & Co., New York City, and copyrighted by the Associated Advertising Clubs of the World. Price, $2.

This book, by one connected with the Federal Trade Commission who has given broad and comprehensive attention to business problems, was written with a definite purpose. It is a message of warning and construction offered in the hope of bettering business conditions and securing sound methods of cooperation. It deals with the fundamentals of cost accounting, merchandising, trade associations, price fixing, trade associations in Germany, commercial education, foreign trade opportunities, business organization of foreign competitors, banking and investment abroad, cooperation in American export trade, the Sherman law, constructive policy of the Federal Trade Commission, the Federal Trade Commission Act, the Clayton law. The book is one that may be very profitably studied by manufacturers in view of the serious problems likely to

# Mechanical Principles Cannot Be Changed

But their APPLICATION may be. When ONE Mechanical Motion can be made to DO THE WORK OF TWO or MORE, EVERYBODY IS BETTER OFF



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ACCURACY STRENGTH
and LONGEVITY

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**Boring Drilling and Milling Machine**

It is Always "ON THE JOB"

LUCAS MACHINE TOOL CO., NOW AND ALWAYS OF CLEVELAND, O., U.S.A.

confront them at the close of the European war and the probable development of merciless foreign competition.

## NEW CATALOGUES AND CIRCULARS

**Roth Bros. & Co.**, Adams and Loomis Sts., Chicago, Ill. Bulletin 182 of direct-current motors and generators.

**J. H. Williams & Co.**, 61 Richards St., Brooklyn, N. Y. Circular of internal and double- and single-end external gages.

**Buda Co.**, Railway Exchange Bldg., Chicago, Ill. Circular of Buda electric storage battery trucks for use in railway terminals, factories, warerooms, storehouses, etc.

**Sprague Electric Works of General Electric Co.**, 527 W. 34th St., New York City. Circular of safety panels and dead front switchboards which minimize the danger of shock.

**Wagner Electric Mfg. Co.**, St. Louis, Mo. Bulletin 114, describing a modern lumber mill and its electrical equipment, illustrating a number of motor applications and types of drive.

**Mesta Machine Co.**, Pittsburg, Pa. Bulletin M, illustrating and describing Mesta improved pickling machines for use in pickling sheets, structural shapes, stamped metal products, pipes, etc.

**R. G. Clyne**, Columbia Bldg., St. Louis, Mo. Booklet outlining service offered in designing special labor-saving machinery, tools and devices, developing inventions, redesigning machinery, etc.

**Vanadium-Alloys Steel Co.**, Pittsburg, Pa. Paper read by Roy C. McKenna, president, on "Crucible Tool Steel" at the annual convention of the sales representatives of the company, January 3.

**Spray Engineering Co.**, 93 Federal St., Boston, Mass. Bulletin 250, illustrating and describing "Spraco" equipment for washing and cooling ventilating air for steam-turbine-driven generators.

**Harrison Safety Boiler Works**, Philadelphia, Pa. Catalogue 710 on Cochrane heaters, designated as a treatise on the utilization of the exhaust system of heating, softening and metering of boiler feed water.

**Federal Machine Co.**, South Bend, Ind. Circular of No. 3 plain-head screw machine with automatic chuck and bar feed. The chuck capacity for round, square and hexagon stock is 1 5/16, 29/32 and 1 1/8 inch, respectively.

**Vacuum Oil Co.**, Rochester, N. Y. Catalogue of horizontal gas engines of small and medium size, treating of classification, field of service, construction, principle of operation, cooling, gas used, methods of lubrication, lubricating oil and deposits.

**Foster Machine Co.**, Elkhart, Ind. Catalogue of the Foster No. 5 screw machine having a bar capacity of 1 13/16 inch and a chucking capacity of 8 inches. The various tools and attachments for this machine are also illustrated and described.

**New Departure Mfg. Co.**, Bristol, Conn. Sheets Nos. 83 FE to 86 FE, inclusive, for loose-leaf binder, illustrating ball bearing applications in drilling machines, ball bearings in jib crane and trolley, the use of ball bearings in disintegrating machines and ball bearings in change speed and right-angle drive gearing.

**Joseph T. Ryerson & Son**, Chicago, Ill. Circular of the Ryerson boiler tube reclaiming machine designed for railroad shops, particularly for the purpose of utilizing short boiler tubes that otherwise would be scrapped. The machine welds short tubes together into tubes of proper length for locomotive service.

**Vanadium-Alloys Steel Co.**, Pittsburg, Pa. Folder descriptive of "Vasco-Marvel," a semi-high-speed steel particularly suited for hot work. The circular gives information on the forging, hardening, cooling and annealing of "Vasco-Marvel" steel. A table of high-speed steel standard classification of extras is included.

**Barnes & Morris**, 182-183 Temple Chambers, London, E.C., England. Circular and booklet of the "Wedge" optical pyrometer, an optical instrument for determining the temperature of furnaces, molten metal, forgings, etc. The instrument is calibrated to cover any range desired between the limits of 500 and 2000 degrees C.

**Whitcomb-Blaisdell Machine Tool Co.**, Worcester, Mass. Catalogue of Whitcomb-Blaisdell planers with second-belt drive, containing a detailed description of the machines and their various parts, all of which are illustrated. Specifications are given for the 20-, 24-, 26- and 30-inch planers. Four different styles of motor drive can be furnished in connection with these planers.

**United Hammer Co.**, 141 Milk St., Boston, Mass. Booklet describing Fairbanks power hammers which are adapted for a great variety of work by the provision of special dies. These hammers are equipped with motor or belt drive as desired. The pamphlet also illustrates special fork hammers and a tire-welding attachment that can be used with any regular pattern Fairbanks hammer.

**T. C. M. Mfg. Co.**, Hunterdon and First Sts., Harrison, N. J. Catalogue illustrating and describing the Morris Thomson semi-automatic thread milling machine especially designed for quick, accurate production of threads by the use of multi-cutters on pieces varying from one to twelve inches in diameter. The catalogue illustrates this line of machines and shows examples of the work done, as well as the types of cutters used.

**Winfield Electric Welding Machine Co.**, Warren, Ohio. Circular entitled "Electric Welding by the Winfield Way," showing the line of spot-welding and butt-welding machines made by this company and describing the principle on which they operate. The circular also shows views of installations of these machines engaged on a variety of work in different factories, and in addition to information on the construction of the machines, cost, etc., gives tables of butt-welding and spot-welding data.

**Leeds & Northrup Co.**, Philadelphia, Pa. Bulletin 866-A, treating of apparatus for the location of thermal transformation points. The bulletin contains charts of transformation curves obtained with the Leeds & Northrup apparatus. It is stated that a complete chart, including all critical points during the heating and cooling of a sample, can be obtained in about thirty minutes. The heating is done in a small electrical furnace, and the apparatus can easily be installed on a table in an office or laboratory.

**Gisholt Machine Co.**, 1202 E. Washington Ave., Madison, Wis. Reprints of recent advertisements in the "American Machinist" on the work done on Gisholt machines and the history of the Gisholt Machine Co. The company builds turret lathes, automatic turret lathes, vertical boring mills, universal tool grinders, horizontal boring and drilling machines, double emery grinders, toolpost tool-holders, solid adjustable reamers, boring-bars, adjustable cutters, special jigs and fixtures, and the periodograph—a workman's time recorder.

**Doehler Die-Casting Co.**, Court and 9th Sts., Brooklyn, N. Y. Catalogue entitled "Creating an Industry," dealing with the die-casting industry from its inception to its present extensively developed state. The book shows interesting illustrations of early castings and molds, some of which date back as far as 1000 B.C. The first part of the book deals with the industry from prehistoric to modern times, and the second part takes up the development in the last decade. Many illustrations are shown of modern die-castings made from various alloys, the composition and chemical properties of which are given.

**Hampden Corundum Wheel Co.**, Springfield, Mass. Catalogue of grinding wheels made of corundum, carborundum, oxylum and emery. This handsome piece of advertising literature contains illustrations of the company's Corundum Hill mine in North Carolina, and other interesting matter on the manufacture and testing of wheels. The safety code for the use and care of abrasive wheels recommended by the National Machine Tool Builders' Association is given, and data on the speeds of wheels, selection of grains and grades of wheels, etc. The wheel list is illustrated, showing the purchaser exactly the shape of wheel listed in each case, thus avoiding misunderstandings and mistakes.

**Albro-Clem Elevator Co.**, Seventh St. and Glenwood Ave., Philadelphia, Pa. Folder on Hindley gearing, defining the distinctive characteristics of the Hindley type of worm-gearing and showing how it differs from the ordinary type of worm-gearing. The company has specialized in the making of Hindley gearing for many years, having made and sold it for application in various types of machines and to operate under varying conditions of load. It is claimed that the Hindley gear has straight-line elements in contact, the projection of which is an area; whereas in the common type a curve is in contact with a straight line, the projection of which is a line; hence the Hindley gear is superior in point of frictional resistance and wear.

**S. K. F. Ball Bearing Co.**, Hartford, Conn. Bulletin entitled "S. K. F. Self-aligning Ball Bearing Hangers and Pillow Blocks," describing the construction of S. K. F. ball bearing hangers and pillow blocks and telling of some of the advantages gained by their use. The book discusses power saving; the use of smaller motors; saving in lubrication and inspection; and reduced fire hazard. Valuable tables of curves and engineering data upon mounting, lubrication, testing lubricants, felt seals, etc., are also included. Announcement is made of the S. K. F. service, by means of which users or prospective users of S. K. F. ball bearing hangers and pillow blocks can submit their problems to the transmission department. The engineers of the company will investigate the conditions and assist in determining the best means of reducing friction losses and selecting an equipment.

## TRADE NOTES

**Light Mfg. & Foundry Co.**, Pottstown, Pa., has opened an office in the Penobscot Bldg., Detroit, Mich. C. F. McRae will be in charge.

**Covington Multiple Drill Co.** has moved from Covington, Ky., and is now located at 2449 W. McMicken Ave., Cincinnati, Ohio.

**Cleveland Metal Products Co.**, 7609 Platt Ave., Cleveland, Ohio, has acquired the business of the Cleveland Foundry Co., and assumed entire management of the business.

**Napier Saw Works, Inc.**, Springfield, Mass., is the successor of the Quality Saw & Tool Works, manufacturers of "Quality" hacksaw blades and metal-cutting specialties.

**Cincinnati Iron & Steel Co.**, Cincinnati, Ohio, is distributing to its business friends the "Cisco" Fahrenheit thermometer of the hand and dial type—a most acceptable fixture for office use.

**J. N. Lapointe Co.**, New London, Conn., manufacturer of broaching machines and broaches, has increased the wages of its employes 10 per cent in addition to the monthly bonus based on the output of the company.

**Exeter Machine Co.**, Pittston, Pa., which recently went into bankruptcy, will be sold at auction February 8. The company built steam engines, and recently completed a large order of 20-inch engine lathes for foreign customers.

**Domestic Machinery Works**, Wissinoming, Philadelphia, Pa., have incorporated their business under the name of Richter Machine Co. Wolfgang Richter of the original firm is president, and F. V. McMullin of the Pennsylvania Forge Co. is secretary and treasurer.

**Chicago Pneumatic Tool Co.**, Chicago, Ill., held an annual convention of the sales and factory organizations at the Great Northern Hotel, January 11-13, inclusive. The company reports that December 31 closed the biggest month and the biggest year in the history of the company's business.

**Parker Rust-Proof Co. of America**, Detroit, Mich., has acquired by purchase the Thomas W. Coslett patents on the "Coslettizing" process for rust-proofing iron and steel. The company also controls the fundamental Richards, Allen and Parker patents on the rust-proofing art. The company will license manufacturers of motor cars, motor car parts, and other products to rust-proof the parts in their own plants.

**George Gorton Machine Co.**, Racine, Wis., is erecting a one-story steel and brick structure, 75 feet high by 200 feet long, with concrete foundation and concrete floor. The building will have a monitor roof, and will be provided with a twenty-ton Pawling & Harnischfeger electric traveling crane. The machines will be individually motor driven throughout, and some new equipment will be purchased.

**Moulton Engineering Corporation**, consulting engineers dealing with hydraulic, electrical, steam, mechanical, electrolytic, structural, architectural and other engineering problems, have opened a New York office at 233 Broadway. The new office will be under the direction of Horace W. Flashman, who for a number of years was associated with the Westinghouse Electric & Mfg. Co. in engineering and commercial work.

**Clark Equipment Co.**, Buchanan, Mich., is a new corporation organized for the purpose of taking over the Celfor Tool Co. and the Buchanan Electric Steel Co. The merger was effected for the purpose of strengthening both companies and enabling customers to be served better than in the past. No change in the manufacturing or selling methods of either company will be made, and the personnel of the organization will remain the same.

**Marshall & Huschart Machinery Co.**, Chicago, Ill., announces that Mr. Marshall, the founder of the company, has resigned as president, but retains a financial interest in the company and will act in an advisory capacity. The following officers were elected at the January 3 meeting of the directors: H. W. Jones, president; George C. Edwards, vice-president; William H. Reid, treasurer; Frank Seese, secretary; and J. R. Porter, general manager. There will be no change in the general policy.

**Shepard Electric Crane & Hoist Co.**, Montour Falls, N. Y., has arranged with the "Free Press," a local newspaper, to publish several columns of "Shepard news" weekly, the object being to inform the men of the various plant activities, and also to interest the town people and attract the class of young men to whom the opportunity to learn a useful trade and secure a practical education would appeal. The first number contains an announcement of the night school classes in the Shepard technical school. Courses are given in blueprint reading, shop mechanics, shop drawing, practical electricity, and shop mathematics.

**Parker Mfg. Co.**, Detroit, Mich., has been organized to manufacture drill chucks. The company will place a complete line of three-jawed keyed type chucks on the market. Gorham C. Parker, formerly sales manager for the T. R. Almond Mfg. Co., is general manager and will be made president when the concern is incorporated. Kenneth P. Albridge, who was formerly associated with the engineering department of the T. R. Almond Mfg. Co., is production manager. The company has located on Milwaukee Ave., Detroit, and is purchasing up-to-date equipment for the plant. The product will be marketed through the usual sources, such as machinery supply dealers and portable drill makers.

**J. H. Williams & Co.**, 61 Richards St., Brooklyn, N. Y., have established a system of bonus payments which will be put into effect for the company's entire organization in Brooklyn and Buffalo, in accordance with the following provisions: Bonuses will be based on thirteen weeks' pay at a time, and paid on the next following payday to all men in the company's employ at the time. The normal rate of bonus based on the rate of pay will be 10 per cent on salaries less than $1250 per year; 7½ per cent on salaries less than $2000 and equal to $1250; 5 per cent on salaries of $2000 or more. The bonuses for hourly pay will be 10 per cent on less than 45 cents hourly rate; 7½ per cent on hourly rates equal to 45 cents but less than 60 cents; and 5 per cent on hourly rates equal to 60 cents or more. Bonuses for all piecework will be figured at 5 per cent, including overtime.

**Kempsmith Mfg. Co.**, Milwaukee, Wis., recently notified its shop employes of an extra payment plan by which all employes remaining with the concern during this year will receive an extra payment amounting to 10 per cent of their total pay. The plan affects about 450 employes and will mean a distribution of about $35,000 in addition to regular wages. The plan provides that employes on the payroll January 1, 1917, who continue in the employment of the company during the year, will receive an extra payment of 10 per cent of their total earnings for the year, distributed as follows: 2½ per cent of the earnings of the first quarter, payable at the end of that period; 5 per cent of the earnings for the first six months, less the sum previously distributed, payable at the end of that period; 7½ per cent of the earnings for the first nine months, less the sums previously distributed, payable at the end of that period; and 10 per cent of the earnings for the year, less the sums previously distributed, payable at the close of the year.